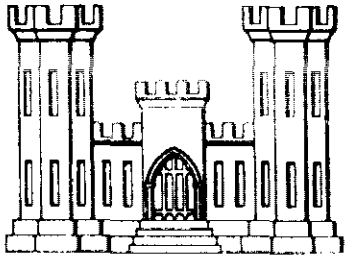
CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK
DAM & RESERVOIR

OTTER BROOK, NEW HAMPSHIRE

DESIGN MEMORANDUM NO.5

GENERAL DESIGN MEMORANDUM



Corps of Engineers, U.S. Army - Office of the Division Engineer

New England Division - Boston, Mass.

JUNE 1955

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
857 COMMONWEALTH AVENUE
BOSTON 15, MASS

Address Reply to:
Division Engineer

Refer to File No.
NEDGW

30 June 1955

SUBJECT: Submission of Design Memoranda, Otter Brook Dam and Reservoir, Connecticut River Basin, New Hampshire

TO: Chief of Engineers
Department of the Army
Washington 25, D. C.
ATTENTION: ENGWE

There are submitted herewith, for review and approval, 12 copies of the "General Design Memorandum" (Design Memorandum No. 5) and 10 copies each of the Design Memoranda on "Hydrology and Hydraulic Analysis", "Geology and Soils" and "Embankment Design" (Design Memoranda Nos. 1, 3, and 7 respectively) for Otter Brook Dam and Reservoir, Connecticut River Basin, New Hampshire, together with one set of full-size drawings for each memorandum, all in accordance with Paragraph 4214.12 of Orders and Regulations.

FOR THE DIVISION ENGINEER:

J. R. THOMPSON
Lt. Col., Corps of Engineers
Executive Officer

8 Incls.
1. Design Memo No. 1 - (Copies 1 to 10, incl.)
2. " " " 3 - " " "
3. " " " 5 - " 1 to 12 "
4. " " " 7 - " 1 to 10 "
5 - 8 - Full-sized drawings for Design Memos Nos. 1, 3, 5, and 7

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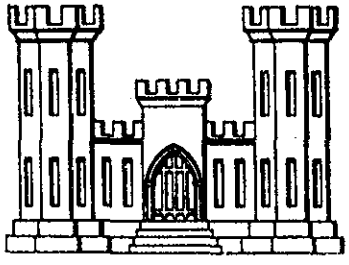

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FLOOD CONTROL PROJECT

OTTER BROOK DAM AND RESERVOIR

OTTER BROOK

CONNECTICUT RIVER BASIN

NEW HAMPSHIRE

INDEX

DESIGN MEMO NO.	TITLE	SUBMISSION DATE
1	Hydrology and Hydraulic Analysis	15 Feb 1955 * 30 June 1955
2	Real Estate Memorandum	4 May 1955
3	Geology and Soils	27 May 1955 ** 30 June 1955
4	Concrete Materials	
5	General Design Memorandum	27 May 1955 ** 30 June 1955
6	Relocations	
7	Embankment Design	27 May 1955 ** 30 June 1955
8	Outlet Works	
9	Reservoir Management	

* Initial submission in Draft to secure approval of spillway design flood and outlet requirements, approved 17 March 1955.

** Submission of Preliminary Draft for discussion and review.

OTTER BROOK DAM AND RESERVOIR

OTTER BROOK

CONNECTICUT RIVER BASIN

NEW HAMPSHIRE

DESIGN MEMORANDUM NO. 5

GENERAL DESIGN MEMORANDUM

C O N T E N T S

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LIST OF TABLES

LIST OF PLATES

OTTER BROOK DAM AND RESERVOIR
OTTER BROOK
CONNECTICUT RIVER BASIN
NEW HAMPSHIRE

A. PERTINENT DATA

a. Purpose — Flood Control

b. Location of Dam

State	New Hampshire
County	Cheshire
City and Town	Keene and Roxbury
River	Otter Brook, 2.4 miles above its confluence with The Branch, 4.9 miles above the Ashuelot River and 31.4 miles from the Connecticut River
Distance from Keene	East northeast 2.4 airline miles

c. Drainage Areas

Otter Brook at Gaging Station	42.3 sq.mi.
Otter Brook at Dam site	47 " "
Otter Brook at The Branch	54.5 " "
The Branch at the Ashuelot R.	100 " "
Ashuelot River at Connecticut R.	421 " "

d. Stream Flow

Record of U.S.G.S. gaging station on Otter Brook Oct. 1923 to Sept. 1953

	Average Rates	
	C.F.S.	C.F.S. Per sq.mi.
Average Annual	71.0	1.67
Maximum year (1938)	110	2.60
Minimum year (1930)	39.4	0.93
Maximum month (March, 1936)	440	10.4
Minimum month (Oct. 1949)	2.88	.068
Maximum day (Sept. 21, 1938)	4040	95.5
Minimum day (Sept. 9, 10, 12, 30, 1953)	1.3	.031

e. Maximum Floods of Record (Peaks exceeding 3,000 c.f.s.)

(Otter Brook at Gaging Station)

Sept. 21, 1938	6,130 c.f.s.
Mar. 18, 1936	3,580 "
Nov. 26, 1950	3,540 "
Nov. 4, 1927	3,180 "
Apr. 12, 1934	3,020 "

f. Spillway Design Flood Data

Peak inflow, full reservoir, c.f.s.	38,000
Total volume of rainfall, inches	24.8
Infiltration rate, inches per hour	0.067
Total volume of runoff, acre-feet	53,150
Total volume of runoff, inches	21.2
Duration of flood, days	4.0
Reservoir stage at start of flood, feet, m.s.l.	781.0
Gates	Closed, inoperative

g. Reservoir

City and Town affected: Keene and Roxbury, N.H.

Pool	Elev.	Area in Acres	Net Storage Acre-Feet	Net Storage Inches of Runoff
Permanent Conservation	701	70	700	0.3
Flood Control	781	375	17,600	7.0
Maximum Surcharge	797.1	444	6,500	2.6
Maximum Wave Fetch	(at elev. 797.0)			1.67 miles

h. Dam

Type	Rolled fill, earth
Length, feet	1,288
Maximum height above stream bed, feet	133
Slopes of Embankment	
Upstream, above elevation 683,	1 on 2½
below elevation 683,	1 on 6
Downstream	1 on 2½
Elevations, mean sea level datum	
Top of dam	802.0
Streambed at downstream toe	665
Streambed at center line	669
Top width	25 feet
Freeboard above spillway design Flood height	4.9 feet

i. Outlet Works

Type - Conduit on rock foundation - Boston Horseshoe Section
Size - 6-foot diameter
Length - portal to portal, feet 589

Gates - Service

Type	Hydraulic slide
Number and size	3-4'6" x 2'-6"
Elevation gate sills, m.s.l.	683.0

Gates - Emergency None

Capacity of Outlets	1 Gate	2 Gates	3 Gates
Reservoir at spillway crest, c.f.s.	775	1390	1500
Reservoir at elevation 797.1, c.f.s.	840	1500	1620

j. Spillway

Type	Uncontrolled, Ogee weir and chute in rock
Crest length	145 feet
Elevation of crest, m.s.l.	781.0
Maximum head, feet (from reservoir surface)	16.1
Peak discharge, c.f.s.	34,500

k. Real Estate

Fee to be acquired, acres	461
Easements to be acquired, acres	152
Total to be acquired, acres	513

Classification, acres	Fee	Easements
Improved Home Sites	12	-
Improved Commercial	10	-
Woodland	349	152
Potential Camp Sites	10	-
Tillage	80	-
Total	461	152

l. Relocations	Existing	Proposed
Concord Road (Route 9), paved, miles	1.2	-
Branch Road, paved, miles	1.6	-
Route 9, 3 miles	*	2.9
Local Roads, paved, 3 miles	0.4	none
Local Roads, gravel, 3 miles	0.3	none
Power and Telephone, distribution, miles	2.4	1.6

* Route 9 replaces both Concord Road and Branch Road.

m. Principal Quantities

Common excavation, (including stripping)	225,000 c.y.
Borrow excavation	864,000 c.y.
Rock excavation	108,000 c.y.
Embankment	
Rolled embankment - impervious	775,000 c.y.
Pervious (including filter materials)	117,000 c.y.
Rock Fill	81,000 c.y.
Concrete	5,660 c.y.
Cement	7,000 bbl.
Reinforcing Steel	327,000 lbs.
Structural Steel	50,000 lbs.

n. Estimated Project Costs (1955 Price Levels)

Project Feature	Cost
Lands and damages	$ 234,000
Relocations	492,000
Reservoir	37,000
Dam (including embankment, spillway and outlet works)	3,253,000
Roads	30,000
Buildings, grounds and utilities	94,000
Permanent operating equipment	30,000
Engineering and design	300,000
Supervision and administration	330,000
Total estimated project cost	$ 4,800,000

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FLOOD CONTROL PROJECT

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30 June 1955

B. PROJECT AUTHORIZATION

1. Authority. - Construction of the Otter Brook Dam and Reservoir was authorized by the Flood Control Act approved 3 September 1954, as a unit of the plan for control of floods in the Connecticut River Basin in lieu of any reservoir or reservoirs previously authorized.

2. The Otter Brook Dam was also among the projects included in the flood control compact adopted by the States of Connecticut, Massachusetts, New Hampshire and Vermont and approved on 6 June 1953, Public Law 52-83rd Congress.

C. SELECTION OF SITE

3. Selection of Site. - There is an urgent need for additional flood control storage to afford the City of Keene, New Hampshire a reasonable degree of flood protection. Keene, one of the principal damage centers in the Connecticut River Basin, is situated on the Ashuelot River where partial control is provided by Surry Mountain Dam. The Otter Brook site is the only feasible site for flood control storage in the watershed of The Branch which enters the Ashuelot River at Keene.

4. Alternate sites in the Connecticut River Basin were considered in preparation of the report submitted in 1940 (see Paragraph 5) and the report of the New England-New York Inter-Agency Committee forwarded to the Chief of Engineers in March 1955. The Otter Brook site was among those with a favorable ratio of benefits to costs and was recommended.

D. INVESTIGATIONS

5. Previous Investigations. - Otter Brook Dam was studied for the "308 Report" (House Document No. 412, 74th Congress, 2nd Session) and for various later reports. It was first proposed for construction in a Review Report on the Connecticut River Basin dated 28 February 1940. This report, however, was not submitted to Congress and authorization did not follow. The project was included in a comprehensive plan submitted to the States in the Connecticut River Basin by the New England Division in 1947.

6. Current Investigations. - Studies for the project plan utilized the basic data obtained for the previous investigations. Hydrological studies were made to review the recommended reservoir capacity and to determine the spillway design flood and outlet requirements. The Design Memorandum on Hydrology and Hydraulic Analysis was prepared and submitted in draft to secure approval of spillway design flood and outlet requirements. Necessary geological and soils investigations of foundation conditions and embankment materials were made. Potential sources of concrete aggregate in the vicinity of the site have been investigated and the results of previous tests reviewed. Appraisals of lands and damages in the reservoir and work areas have been made. Relocations of roads within the reservoir have been discussed with State and City officials and preliminary plans for relocations have been prepared. The U. S. Bureau of Public Roads was asked for advice as to the need for a bridge over the dam and advised that it is not desirable or needed. The U. S. Public Health Service has been requested to report on mosquito control requirements and the U. S. Fish and Wildlife Service has investigated the fish and wildlife resources of the area. These reports will be contained in the Design Memorandum on Reservoir Management. Studies have been made of the recreational potentialities of the reservoir. Revised area-capacity curves have been prepared from aerial photographic and plane table surveys prepared on a scale of one inch equals 200 feet.

7. Public Hearings. - The Corps of Engineers has not held public hearings on the Otter Brook project.

8. The Subcommittee on Flood Control, Committee on Public Works of the U. S. House of Representatives heard testimony regarding the project during the course of hearings on the 1954 Flood Control Omnibus bill. On May 19, 1954 the Honorable Senator Robert D. Upton of New Hampshire; Congressman Norris Cotton of New Hampshire; Congressman Chester E. Merrow of New Hampshire; Mr. Philip Shutler, Director of Connecticut River Flood Control Commission; Mr. Frank Merrill, Commissioner of Public Works and Highways, New Hampshire; Mr. Laurence F. Pickett, Mayor of the City of Keene; Mr. Arthur Whitcomb, representing the Keene Chamber of Commerce and Mr. Daniel Eneguess, Executive Secretary of the Monadnock Region Association all requested authorization of the project. Statements by the Honorable Styles Bridges, Senator from New Hampshire and Mr. Carlson S. Sharpe, City Manager of Hartford, Connecticut, also requested favorable consideration of the project.

9. A hearing was held by the Connecticut River Flood Control Commission in Keene, New Hampshire, on October 22, 1954, for the purpose of obtaining information as to the desire of state and local interests for a permanent conservation pool as a part of the project. Representatives of the City of Keene, The Monadnock Region Association, The Society for Protection of New Hampshire Forests and several individuals urged that a permanent pool be provided.

E. LOCAL COOPERATION

10. Local Cooperation. - Local cooperation is not required. All costs of the project will be met with funds of the United States.

11. The State of New Hampshire through its Water Resources Board has expressed its concurrence with the construction of Otter Brook Dam and the project is among those included in the Connecticut River Compact which provides for reimbursement of tax losses and other economic losses in the upstream states by the downstream beneficiaries. The New Hampshire Department of Public Works and Highways has postponed initiation of public works valued at $2,500,000 in an effort to reduce relocation costs which would result from construction of the project and has also induced commercial enterprises not to build in the area.

F. LOCATION OF DAM AND TRIBUTARY AREA

12. Location of Dam and Reservoir. - The proposed Otter Brook Dam and Reservoir are located in southern New Hampshire at the easterly side of the Connecticut River Basin. The dam site is located at mile 2.4 on Otter Brook on the boundary between the City of Keene (1950 population 15,638) and the Town of Roxbury, (population 117) Cheshire County New Hampshire. The proposed reservoir at full pool elevation 781 feet, m.s.l., would extend upstream from the dam site 2.3 miles through Keene and Roxbury. The location of the proposed dam and reservoir with respect to completed flood control projects in the Connecticut River Basin is shown on Plate No. 1-1 in the Design Memorandum on Hydrology and Hydraulic Analysis. The project location is shown on Plate No. 5-1, the vicinity map on Plate No. 5-2 and the reservoir map on Plate No. 5-3. An aerial mosaic showing the reservoir area and vicinity is included as Plate No. 5-4.

13. Description of the Otter Brook Basin. - The Otter Brook Watershed is bounded on the east by the Merrimack River Watershed and on the north, west and south by other parts of the Ashuelot River Watershed. The area tributary to the dam is roughly diamond-shaped, about 12 miles long and with a maximum width of 7.5 miles. The drainage area is rural with the exception of the small population centers of East Sullivan, Munsonville and Nelson. The land is largely wooded with steep slopes conducive to rapid runoff. A map of the drainage area is shown as Plate No. 1-2 in the Design Memorandum on Hydrology and Hydraulic Analysis.

G. RECOMMENDED PROJECT PLAN

14. Recommended Project Plan. - The recommended project plan for the Otter Brook Dam and Reservoir includes the construction of a rolled-fill earth dam 1288 feet in length across the Otter Brook valley, outlet works founded on bedrock under the dam; a concrete ogee spillway in a chute or channel excavated in a natural saddle in the right abutment; a utility building; fire protection system and quarters for the operator consisting of an existing dwelling located on the site. The project requires relocation of portions of New Hampshire Route 9 and Branch Road, both in the state highway system. The structures, improvements and relocations are described in detail in paragraphs 28 through 38. The various structures and topography at the site are shown on Plate No. 5-5.

H. DEPARTURES FROM PROJECT DOCUMENT PLAN

15. Departures from Project Document Plan. - Otter Brook Reservoir was not included in any approved survey report. Consequently there are no departures from a project document plan.

I. HYDROLOGY

16. Spillway Design Flood. - For spillway design a storm was developed based on the estimated maximum possible precipitation over the drainage area. The total depth of rainfall over the basin above the dam site is 24.8 inches in 72 hours. Losses including infiltration are assumed at a maximum rate of 0.2 inches for three hours which nets a rainfall excess of 21.2 inches. The adopted spillway design flood with a peak value of 38,000 c.f.s. was constructed by applying the rainfall excess to a 3-hour unit hydrograph. Routing the spillway design flood through the reservoir, assuming an initially full pool at the spillway crest elevation of 781.0 feet, m.s.l., resulted in a maximum surcharge elevation of 797.1 and a maximum discharge of 34,500 c.f.s. as shown on Plate No. 1-15 in Design Memorandum No. 1.

17. Channel Capacity. - Field investigations have determined that the channel capacity of Otter Brook below the dam site is approximately 1000 c.f.s. However, the operation of the proposed reservoir will be limited to the restricted channel capacity of the Ashuelot River in Keene, New Hampshire, which is also approximately 1000 c.f.s. but has a contributing drainage area of 310 square miles.

18. Flood Control Outlets. - Release of the impounded flood waters will be dependent upon the channel capacity of 1000 c.f.s. in the City of Keene, N.H. The selected conduit will discharge this amount with a pool elevation of 725 feet, m.s.l. equivalent to 16 percent of the flood control storage. The discharge capacity of 800 c.f.s., with a pool elevation of 709.5 feet, m.s.l., will satisfy diversion requirements. Reference is made to Plate No. 1-26, Outlet Rating Curves, in Design Memorandum No. 1.

19. Freeboard. - With the top of dam at elevation 802.0, a freeboard of 4.9 feet above a maximum pool elevation of 797.1 m.s.l. is provided.

J. GEOLOGY

20. Geology. - Otter Brook occupies a pre-glacial valley which has been deeply filled with glacial outwash and till. The stream flows in a channel located high on the western side of the old valley.

21. At the dam site, a bedrock spur projects from the valley wall to form the right abutment of the proposed dam. The spur is exposed or is available at shallow depth providing foundations for spillway and outlet structures. The bedrock is mica schist with granitic phases and occasional granite dikes.

22. The thin overburden on the right abutment consists of gravelly, silty sand and forest debris. On the left abutment where the rock is deeply buried, the overburden is glacial till underlain by variable deposits of outwash materials. In the valley bottom the overburden is variable silty, gravelly sand. A shallow layer of silt occurs throughout the narrow flood plain on the easterly side of the stream. A more complete description of the geology of the site is included in the design memorandum on geology and soils.

K. ALTERNATE PLANS

23. Type of Dam. - No studies were made for alternative types of dam. A concrete dam at this site would involve very expensive construction in the east abutment. A rockfill dam would require expensive quarrying operations to develop the necessary materials and the substitution of rockfill for earth embankment would increase the cost owing to the considerable depth of overburden on the left abutment.

24. Location of Embankment. - Initial studies, based on a preliminary survey, indicated that minimum embankment volume would be obtained by using a location about 500 feet upstream. Subsurface explorations were laid out on this basis. The borings revealed that the bottom of the valley is filled with a deposit of sands and gravels which would involve a cutoff and drainage problem. Additional borings were made to more fully develop foundation conditions in the valley bottom, and the embankment was located where the foundation is most suitable. The survey of the site indicated that the selected location results in the minimum embankment volume. The various embankment locations studied varied from 500 feet upstream to 200 feet downstream of the recommended alignment.

25. Spillway. - In addition to the ogee weir and chute spillway in the recommended project plan, studies were made for a side channel spillway in the saddle in the westerly abutment and for an ogee weir at the end of the dam. Studies were also made for a chute spillway curving more rapidly toward the river. These alternates were found to be more expensive than the recommended plan. The shallow rock cuts of the recommended plan were also considered less conducive to slides than the relatively deeper channels of the side channel spillway.

26. Consideration was also given to a higher spillway elevation in order to reduce the amount of rock excavation in the spillway chute by storing a part of the spillway design flood in the reservoir below spillway crest. This was not feasible owing to the relatively small reservoir area at this site which resulted in excessive increases in embankment volume.

27. Spillway Length and Surcharge. - Studies were made to determine the economic spillway length and surcharge, giving consideration to the cost of embankment, outlet works, highway relocation and spillway rock excavation and weir concrete. Spillway length-surcharge-cost curves were developed for spillway lengths varying from 300 feet, with ten feet surcharge as used for preliminary estimates, to 120 feet with 18-foot surcharge. The most economical spillway length was found to be 145 feet with a corresponding surcharge of 16.1 feet. It was also found that a five-foot spillway approach depth, the minimum which would give good spillway discharge characteristics is the most economical.

L. DESCRIPTION OF PROPOSED STRUCTURES AND IMPROVEMENTS

28. Earth Dam. - The project plan provides for the construction of a rolled-fill earth dam 1288 feet long with a maximum height of 133 feet above the stream bed at center line of dam. The top width of the dam will be 25 feet, accommodating

a paved access road. The top elevation is 802.0 m.s.l. providing for 16.1 feet of spillway surcharge and 4.9 feet of freeboard. The alignment of the dam is curved to position the dam where the foundation is most favorable, to establish the outlet works normal to the embankment centerline and approximately parallel to the riverbank and to abut the dam at the rock knob adjacent to the spillway channel. The dam will be largely of homogeneous impervious section with pervious drainage blankets and rockfill on gravel bedding slope protection. Side slopes on both upstream and downstream sides will be 1 vertical on 2½ horizontal for the full height except at the upstream toe where the slope will be 1 vertical on 6 horizontal below Elevation 683. Embankment details are shown on Plate No. 5-5. Above elevation 683.0 the upstream face will be protected by six feet of rockfill on three feet of gravel bedding. The downstream face will be protected by two feet of rockfill on three feet of gravel bedding. A rockfill toe faced with large rocks, will be provided in the stream bed downstream of the dam. Specifications will also require large rocks adjacent to the retaining wall at the intake.

29. Several conditions influenced the type and design of embankment. They are (1) The availability of glacial till (predominately CL and SC) in deep deposits close to the dam, (2) The relative scarcity and cost of pervious soils, (3) The numerous cobbles and boulders in the available pervious material, (4) The relatively large amount of rock available from excavations and from boulders in the borrow material and (5) The relatively pervious outwash materials in the valley bottom and under the left abutment.

30. The largely homogeneous section with pervious blankets was adopted to use the readily available impervious material with a minimum of the relatively scarce pervious material. Provision will be made to vary the established thickness of rock fill slope protection during construction in order that any excess available rock may be used to best advantage in resisting erosion and improving the stability of the slopes. The thicknesses of gravel bedding and pervious horizontal blankets were established to permit the use of 1½-foot lifts thus allowing the use of boulders up to one foot in maximum size in order to keep the quantity of oversize boulders at a minimum. The relatively pervious outwash materials under the dam required the provision of an upstream impervious blanket and downstream drainage trench to reduce and control seepage through the foundation. A cut-off and exploration trench will be provided at the centerline of dam to permit inspection of the overburden and the bedrock in the right abutment. Depth of the trench will be about five feet except in the valley bottom where some of the more pervious materials will be cut off. Grouting of the bedrock in the right abutment will be specified. However, provision will be made for omission of grouting if no open joints or badly fractured rock are encountered when the cut-off trench is excavated.

31. Outlet Works. - a. General. - The outlet is located on the right bank of the river and will be founded on bedrock. Details are shown on Plate No. 5-6. The outlet works will consist of the intake, with stop log facilities for maintenance and emergency use in lieu of emergency gates; gate structure with three 2'-6" x 4'-6" hydraulically operated slide gates and controls; a 6'-0" diameter

horseshoe shaped conduit approximately 540 feet long; stilling basin, rock bank protection and service bridge. Consideration was given to the use of rolled girders and also plate girders in 2, 3, and 4 spans in lieu of the truss shown on Plate No. 5-6. It was found that the truss is the most economical design.

b. Intake. - The invert of the intake and the gate sill will be at elevation 683, 12 feet above the original stream bed. The upstream end of the intake channel will be notched out of the rock and earth in the side of the river bank. At the gate structure the approach channel will be 24 feet in width. On one side will be a retaining wall supporting the toe of the dam and on the other will be a concrete facing on the excavated rock. A platform will be provided on the upstream side of the gate structure at elevation 704. The piers between gate passages will be elongated to provide a conservation weir discharging into the central gate passage. The conservation weir, a rectangular box formed by elongating the piers between the gates, will be provided with a total of five stop log openings to permit flexible control of the permanent conservation pool. A six-inch low flow outlet through the conservation weir will permit drawing off the cooler water from the bottom of the pond during low flow periods. Drainage of the pool to approximately elevation 683 can be accomplished, if necessary, by using the two outside gates. No special provision will be made for trash racks. Control of trash will be accomplished by construction of a log boom. In the event trash racks are found necessary after the project is placed in operation, trash racks may be placed in the stop log slots.

c. Gate Structure. - The gate structure will be of reinforced concrete of the dry well type. It will be located at the upstream toe of the dam and provided with a service bridge for access. Gate cylinders will be located in a 25-foot diameter chamber, 20.5' high at the bottom of the structure. The upper part of the structure will be 16-foot inside diameter and 89.5' high. The above dimensions are tentative and subject to more detailed design. The chamber and cylinder will be circular inside but the outside will be made octagonal. An octagonal, concrete operating house will surmount the gate structure.

32. Gates and Operating Equipment. - Three $2\frac{1}{2}$ x $4\frac{1}{2}$ foot slide gates with sill elevation at 683.0 will be located in the base of the gate structure. Hydraulic cylinders will be located above and directly over the gates. Details of the intake structure showing location of operating and auxiliary equipment are shown on Plate No. 5-7.

33. Spillway. - The spillway will be located in a natural saddle in the right abutment and separated from the dam by a rock knob which rises above the elevation of top of dam. The existing saddle will be deepened and widened to form the spillway channel. The weir will be a low concrete ogee section founded on bedrock and 145 feet in length at spillway crest elevation of 781.0 m.s.l. The weir will have a height of five feet at the upstream face and about six feet at the downstream toe. The approach channel will be excavated in rock and earth to a width of 142.5 feet. Downstream of the weir the channel, also in rock, will converge into a chute 60 feet wide which will extend about 850 feet from the weir at which point the rock ends. Earth overburden downstream

of the chute will be excavated to slightly above stream bed elevation and used in the dam, thus greatly reducing the amount of erosion and deposition downstream in the event of spillway discharge. Rock spoil will be placed on the left bank of the brook, downstream of the spillway channel, to reduce bank erosion during low to moderate spillway discharges. The concrete weir will end at the rock in the sides of the spillway channel without end walls or facing. However, provisions will be made for placing a concrete lining at the ends of the weir in the event the rock is found to be badly fractured or weathered when the channel is excavated.

34. Diversion Plan. - The plan of diversion is controlled by three basic considerations (1) The necessity for an impervious blanket in the valley upstream of and under the upstream part of the dam (2) The existing blanket of silt and organic material in the east side of the valley bottom and (3) The savings in cost of conduit, intake structure and service bridge resulting from raising the gate sill elevation above the stream bed level. The plan of diversion provides for the placement of all embankment materials in the dry, except for a few yards of rock fill, the processed gravel in the downstream drainage trench and portions of the upstream impervious blanket. Operations will be accomplished in sequence as follows:

(a) A first stage diversion channel will be excavated in the silt at the left side of the valley bottom. The excavated silt will be placed upstream of the dam to augment the existing natural silt blanket. Under the dam the silt adjacent to the west side of the diversion channel will also be removed and a small dikeof impervious embankment material will be placed to form the west bank of the diversion channel. Material at the ends of the diversion channel will be excavated last so that the work of excavation may be prosecuted in areas free of flowing water.

(b) The present river channel will be plugged near the upstream end of the diversion channel to divert the river. A small temporary cofferdam will be placed immediately upstream of where the diversion channel rejoins the river.

(c) The remaining silt between the diversion channel and the river will then be stripped and placed in the old river channel upstream of the dam to form an impervious silt blanket.

(d) The impervious fill will be placed to elevation 683.0 in the west side of the cofferdam including the old river channel.

(e) Additional impervious fill will be placed to form the remainder of the west end of the embankment cofferdam.

(f) Rockfill slope protection will be placed on the lower portion of the west end of the embankment cofferdam omitting rockfill on that part of the slope where the diversion cofferdam is to be abutted.

(g) At the beginning of the second construction season final diversion will be accomplished by constructing a diversion cofferdam, consisting of spoil or random material, across the diversion channel from the upstream face of the east end of the incomplete embankment cofferdam to the east bank of the diversion channel. This material will be dumped into flowing water during a period of low or moderate flow.

(h) As soon as diversion is effected the diversion channel will be cleaned up, the east side of the embankment cofferdam foundation will be stripped, the impervious blanket placed and the embankment cofferdam completed to elevation 711.

(i) Upstream of the dam the diversion channel will be filled by dumping spoil from Branch Road into the water to complete the upstream spoil blanket. The downstream, temporary cofferdam will be removed thus readying the site for the main embankment operation.

Operations (a) through (f) are shown on Plate No. 5-9 and constitute the first stage of the diversion plan. Operations (g) through (i) are shown on Plate No. 5-10 and constitute the second and final diversion. The first stage will be accomplished in the first construction season while the final diversion will be effected following the spring runoff of the second construction season.

35. Administrative Facilities. - The planned Government administrative facilities consist of a combination utility building and garage 32 feet wide by 65 feet long. The building will include office, toilet, storage, workshop and garage facilities for housing Government equipment. The standby unit will be located in the Utility Building. The Utility Building will be constructed immediately after award of the contract so that it may serve as the Government field office during construction.

36. Housing Facilities. - The minimum housing facilities considered essential for this installation are living quarters for the damtender. The location of the damtender's residence in the vicinity of the dam is necessary due to the frequent need to operate gates on short notice at any hour of the day or night; to afford frequent observation of rainfall and reservoir stages; to facilitate communication during emergencies and to minimize vandalism of Government property. The housing facilities will consist of an existing seven-room house with oil heat and hot water. It will be necessary to install hardwood flooring and possibly make some other improvements or minor repairs.

37. This house is presently utilized as a summer camp or "retreat" and its value as such will be largely destroyed by the proximity of the dam. No housing will be provided for the assistant damtender or other help employed at the dam. The damtender will be provided with a garage for his personal auto either by moving an existing garage acquired with the land acquisition for the reservoir or by new construction.

38. Reservoir Clearing. - It is planned to clear the portion of the reservoir below elevation 703, two feet above the top of the conservation pool. The area at this elevation is approximately 76 acres of which about 30 acres are wooded. Due to the relatively small area, reservoir clearing will be included in the contract for construction of the dam.

39. Utilities. - a. Power. - A single phase 2 wire, 2300 volt electric distribution line extends along Peg Shop Road through the site. Three phase 2300 volt power is available in Keene at the corner of Roxbury Street and North and South Lincoln Streets at a distance of 1.8 miles. The existing line will be reconstructed to provide 3 phase open Y 240 volt service at the site. Details of connections and services on Government property will be given in the detailed design memorandum on the outlet works. There will be no cash requirement for this work but a guarantee of a minimum monthly charge of approximately $75.00 for a period of five years will be required.

b. Telephone. - Telephone service is available at the site. If necessary, one or two additional circuits may be added to provide service to the Government field office and contractor.

c. Water. - Small quantities of water for domestic purposes may be obtained from the existing wells at the site. Nearest city water is at the intersection of Branch Road and Roxbury Road, a distance of 0.8 miles. Water for increasing the moisture content of the embankment may be obtained from Otter Brook. This water will also be tested for use in mixing concrete. The well presently serving the proposed operator's quarters will provide water for the utility building. Water to protect Government property from fire will be obtained by constructing a small combination pump and hose house adjacent to the stilling basin. The fire pump will provide 250 gpm at 50 pounds pressure or 500 gpm at 10 pounds pressure at a hydrant to be located between the operator's quarters and utility building. Consideration will also be given to grading the impervious borrow area to form a high level storage pond in lieu of providing the fire pump adjacent to the stilling basin.

M. ACCESS ROADS AND RAILROAD FACILITIES

40. Highways. - The site is located on Branch Road, an 18-foot paved road which follows Otter Brook between Route 101 and Route 9. Branch Road originates 2.9 miles southeast of Keene where it leaves Route 101 and extends northerly 2.3 miles to the site. The site may also be reached from Keene via Peg Shop Road, a distance of 2.7 miles over steep, winding paved roads or northeasterly from Keene via Route 9 and southerly via Branch Road.

41. Upon completion of relocations, reconstructed Route 9 will be adjacent to the dam and will serve as the main access road.

42. Railroad Facilities. - The Boston and Maine Railroad serves Keene, which is the nearest railroad station. Several sidings have ample capacity for delivery of materials and equipment. Ramps are available at some of the sidings, but there are no other unloading facilities. At Joslin there are two small sidings, a privately owned cement hopper and a spur track which is in poor condition.

N. VIEWS OF CONSULTANTS

43. Consultants. - Otter Brook Dam is a relatively simple structure. There were no design problems which warranted the use of outside consulting engineers and geologists. Consultations were held with specialists from the office of the Chief of Engineers and their views are reflected in the project plan.

O. SOURCES OF CONSTRUCTION MATERIALS

44. Materials for Earth Embankment and Blanket. - A substantial portion of the material for earth embankment will come from the spillway excavation. It is expected that this excavation will be worked in the early stages of embankment construction. An ample amount of additional embankment material is obtainable from Borrow Area "C" located above the east abutment of the dam. Use of these materials in the later stages of the dam construction will reduce the amount of haul required down the steep easterly abutment. Materials for the blanket upstream of the dam will be obtained from the stripping, supplemented if necessary, from borrow sources. On completion of borrow excavations, the borrow area will be rough graded but will not be topsoiled or otherwise surfaced. A screen of trees, 100 feet in width, will be left undisturbed between the borrow area and Relocated Route 9.

45. Materials for Pervious Fill and Gravel Bedding. - Limited quantities of gravel for pervious blankets and gravel bedding are available above the water table in Borrow Areas "A" and "D" in the reservoir. Additional materials can be developed below the water table or by excavating the bed of Otter Brook and lowering the water table.

46. Materials for Rockfill. - Ample quantities of rock will be available from required excavation and as boulders from borrow excavation. Requirements will be adjusted to utilize all available rock.

47. Concrete Aggregates. - a. General. - The quantity of concrete required in the construction of spillway and outlet works structures is 5,000-6,000 c.y. With this relatively small quantity, aggregate investigations have been limited to commercial sources within a 25-mile radius of the site.

b. Nearby Sources. - The nearest commercial source of concrete aggregates is the Arthur Whitcomb Company, Swanzey, New Hampshire. This company processes sand and gravel from several pits located at a maximum haul distance of six miles from the site, and also operates a transit mix service 3½ miles from the site. In 1948 aggregates from this source were used in the construction of Edward McDowell Dam at West Peterboro, New Hampshire. Additional tests of this source are underway.

c. Other Sources. - There are no other commercial aggregate sources in the near vicinity of the site. The nearest other commercial source, the Northfield Sand and Gravel Company, Northfield, Massachusetts is located about 25 miles from the dam site. Aggregates from this source were tested in 1947 by the Waterways Experiment Station and were used in 1948 in the construction of Tully Dam, Athol,

Massachusetts. Check evaluation tests are being performed on stockpiled materials from this source. More complete information on concrete aggregates is included in Design Memorandum No. 3, Geology and Soils. Design Memorandum No. 4, Concrete Materials, will be prepared when testing is complete.

P. RESERVOIR MANAGEMENT AND PUBLIC USE

48. Existing Recreation Facilities in the Region. - The recreation industry is the largest producer of revenue in the State of New Hampshire. The major portion of the recreation facilities in the state has been developed by private interests. However, there are extensive developments in several of the State Parks.

49. The reservoir area is located in the Monadnock region of southwestern New Hampshire. The dam site is about 15 miles easterly of the Vermont line at the Connecticut River, and the same distance north of the Massachusetts line. In this location, the site is adjacent to major tourist routes from the south and west to the lake and mountain vacation centers of the state. There are many small lakes and ponds in the region but few are available for public use. There are three state parks within 20 miles of the reservoir area, but facilities are limited to camping, hiking, and picnicking. It is understood that public facilities are also to be developed at Lake Spofford about 10 miles west of the project.

50. Recreational Resources of the Project. - The reservoir area has the shape of a cone with the tip at the dam. The open lands are confined to the valley bottom and have a maximum width of about 600 feet at the upper end of the reservoir. The sides of the reservoir are generally steep and heavily wooded. The water quality is good and suitable for swimming. The natural resources of the project area lend themselves to day use, such as picnicking, fishing and swimming.

51. Contacts with State and Local Officials. - State and local officials have discussed the possibility of a permanent pool at the dam, principally for local use. The need for such facilities in the area has been emphasized by several organized groups.

52. Potential Recreational Activities. - A permanent pool, 70 acres in surface area, will be maintained at elevation 701 without appreciable increased cost of the project. The development of facilities such as bath houses and picnic areas would be provided by others under a long term license. The prospective licensee, either the City of Keene or the State of New Hampshire, will be determined in the near future. Details of the proposed development will be included in the Design Memorandum on Reservoir Management.

Q. REAL ESTATE REQUIREMENTS

53. Guide Taking Line. - a. General. - The acquisition of land will be in general conformance with criteria contained in multiple letter from the Chief of Engineers, ENGWD - ENGKL, dated 12 October 1953, Subject: "Real Estate Land Acquisition Policy for Civil Works Projects".

b. Land to be Acquired in Fee Simple. - Current criteria provide for the use of the 5-year flood elevation as the basis for determining the amount of land for which the fee simple title will be acquired. The stage frequency curve given on Plate No. 1-20 of the Design Memorandum on Hydrology and Hydraulic Analysis shows that the reservoir will reach elevation 754 on an average of once in five years. In order to allow for irregularities in survey work and frequency determination, the five-year frequency elevation was rounded off to 755. It is recommended that elevation 755 be used as the guide taking line for fee simple acquisition. Fee simple acquisition is also recommended for the work and borrow areas, right-of-way for highway relocation and the very steep and narrow strip of land on the east side of the reservoir between the 755 contour and the relocated highway.

54. Flowage Easements. - The real estate policy provides that the flowage easement guide taking line be based on the "project design flood". No project design flood has been developed for Otter Brook Reservoir. Storage requirements were determined on the basis of a comparison with requirements at other reservoirs and from studies of probable operation during several major floods. This procedure is in accord with current approved practice as indicated in paragraph 1-07 of Civil Engineer Bulletin No. 52-8, "Standard Project Flood Determinations". In lieu of basing easement limits on a project design flood it is recommended that easement limits be based on the spillway design flood. This recommendation is based on the following factors:

(1) There are no existing improvements between the spillway crest at elevation 781 and maximum surcharge at approximately elevation 797.

(2) A reasonable allowance for induced surcharge would have to be made. This would be at least five feet, or to elevation 786.

(3) The land area from elevation 786 to elevation 797 is not great, only about 48 acres with an estimated value of about $2,000.

(4) Interest has been expressed in developing cottage sites in the area around the reservoir overlooking the permanent pool. Such cottages could be expected to be located as close to the water as possible. This type of development within the surcharge range would create a hazard and interfere with maximum flexibility of reservoir operation. Damage payments, in the event even a few cottages were so constructed and subsequently flooded, would greatly exceed the present value of the land or the cost of flowage easements thereon.

55. Real Property Taking Line. - In establishing the real property taking line, the guide contour taking line was modified to conform to sound real estate practice. Tract boundaries were followed where possible or tracts divided so as to permit future economic use thereby eliminating severance damages as far as possible. A complete report of the real estate requirements is included in the Real Estate Memorandum.

56. Land Requirements. -

Estate	Acreage
Fee Simple Title	461 *
Flowage easements & easement for Stream Bank Protection	152

* Includes 52 acres for highway relocations.

R. RELOCATIONS

57. Highway Relocations. - A single highway relocation will be required. It will have a length of 2.9 miles and will replace parts of three separate roads having a total length of 3.2 miles within the work and reservoir areas. The highway relocation will provide a replacement for Branch Road and ultimately will form part of a Route 9 bypass around Keene. The State of New Hampshire will accomplish the relocation and will provide a portion of the necessary funds for the work. These highway relocations and local roads to be discontinued will be described in detail in Design Memorandum No. 6, Relocations.

58. Utility Relocations. - Existing telephone and power lines along Route 9, having a length of 1.3 miles will be relocated outside the reservoir. The relocated length, including a reservoir crossing, will be 1.6 miles. Distribution lines dead ending within the reservoir will be removed. The existing power and telephone lines crossing the work area will be reconstructed and will provide service to the dam. Complete details will be included in Design Memorandum No. 6, Relocations.

S. COST ESTIMATES

59. Cost Estimates. - The total estimated cost of the project is $4,800,000 which is the same as the latest approved estimate. A summary of the cost of the various features of the work described in this design memorandum is given in Table I. Breakdown estimates are given in Table II, starting on Page 25. The increase in cost of Lands and Damages is due to additional improvements constructed since preparation of the original estimate and inclusion of flowage easements on lands within the increased surcharge range. The increased cost of relocations is the result of price level changes. Reductions in cost of the dam and associated features result from modifications made in the plans during the design studies.

TABLE I

SUMMARY OF FEDERAL COSTS
(1955 Price Level)

ENR Construction-Cost Index 660 (1913 = 100)

Project Feature	Cost
Lands and Damages	$ 234,000
Relocations	492,000
Reservoir	57,000
Dam (including embankment, spillway, and outlet works)	3,253,000
Roads	50,000
Buildings, grounds and utilities	94,000
Permanent operating equipment	30,000
Engineering and Design	300,000
Supervision and Administration	330,000
Total estimated project cost	$4,800,000

T. SCHEDULES FOR DESIGN AND CONSTRUCTION

60. Design. - Design of the outlet works and remaining portions of other features of the dam and appurtenances, and preparation of contract plans and specifications are scheduled for fiscal year 1956. Design and preparation of contract plans and specifications for the Route 9 relocation will be accomplished by the New Hampshire Department of Public Works under an agreement. Cost of design is estimated at $160,000 including $15,000 for preparation of highway plans.

61. Construction. - It is estimated that two full construction seasons will be required for construction of the project with closure of the channel commencing in the spring of the second season.

62. Contingent on the availability of the necessary funds, construction of the dam and appurtenances will be accomplished under a single continuing contract to be awarded in fiscal year 1957. During the 1957 construction season the contractor will construct the outlet conduit, stilling basin and lower part of the intake structure. He will also construct the utility building which will be used as the government field office and parts of the cofferdam and embankment forming stage 1 of the diversion plan (See paragraph 34). Such other work as clearing and stripping the dam site, preparation of borrow areas, grading for access and haul roads and any other work not contingent upon embankment construction may also be accomplished in the first season.

63. During the 1958 construction season, the contractor will construct the diversion cofferdam, embankment cofferdam and the dam embankment. Work on the intake structure will continue. Part of the embankment fill and rock fill slope protection will be obtained from the spillway excavation. Late in the season the service bridge and concrete spillway weir will be constructed.

64. Highway relocation will be accomplished during the first construction season under an agreement with the New Hampshire State Department of Public Works which will administer the contract.

65. Separate contracts for utility relocation and for modernization of operator's quarters will be awarded in Fiscal Years 1957 and 1958, respectively.

66. Funds Required. - The construction schedule is based on the assumption that initial construction funds will be made available for the project on 1 August 1956. Accordingly, it is estimated that funds will be required by fiscal years approximately as follows:

Fiscal Year	Construction Schedule Amount Required
1956	$ 160,000 (planning)
1957	1,300,000
1958	1,740,000
1959	1,500,000
Subtotal	$ 4,700,000
Allotted to date (advance planning)	100,000
Total	$ 4,800,000

U. RESERVOIR REGULATION

67. Regulation for Flood Control. - Under the plan of operation, the normal gate setting will be with the two outside gates closed and the central gate open. This plan will afford automatic retarding action in the event of a flash flood or mechanical failure affecting the operation of the gates. For minor floods this automatic operation will provide adequate flood control. During moderate or large floods, the gates will be operated as necessary to secure maximum stage reductions at downstream damage centers. A small opening will be left to provide a flow of water to maintain fish life in Otter Brook downstream of the dam.

68. Regulation of Otter Brook Reservoir in conjunction with the existing Surry Mountain Reservoir for the flood of September 1938 (flood of record), that of March 1936, and a Standard Project Flood for Keene, New Hampshire, is described in detail in Design Memorandum No. 1, Hydrology and Hydraulic Analysis.

69. Regulation of Conservation Pool. - Regulation of the conservation pool will be accomplished by means of the conservation weir with stop logs at approximately Elevation 701.0 supplemented by a 6-inch low flow outlet for fishery purposes. If winter conditions make it necessary, some of the stop logs will be removed so that the central gate may be submerged. Releases will be controlled by operating the gates. The low flow outlet will provide a discharge capacity of 4.5 c.f.s. with the pool at Elevation 701.0.

V. OPERATION AND MAINTENANCE

70. Plan of Reservoir Operation. - The Otter Brook Reservoir will be operated for the control of floods both in the Ashuelot River Basin and as a unit in the comprehensive plan for flood control in the Connecticut River Basin. In addition, the conservation pool will have recreational value. Operation of the outlet works will be under the supervision of the Engineering Division of the New England Division.

71. During flood emergencies, the following conditions will govern the regulation of the reservoir:

a. When the predicted stage of the Ashuelot River at Keene, N.H. exceeds 472.5 feet elevation (Local Datum).

b. When the predicted stage of the Connecticut River at Montague City, Massachusetts exceeds a stage of 28 feet. (Approximately 108,000 c.f.s.).

72. Maintenance. - The dam and appurtenant structures will be maintained and operated by a staff consisting of a resident damtender (Wage Board Grade 13), an assistant damtender (Wage Board Grade 8), and 1 or 2 part-time employees. Maintenance will be based on regular, detailed inspection of the entire works, including all operations necessary to preserve the structures. The staff will be under the general supervision of the Operations Division of the New England Division.

73. Annual Charges. - Annual charges given in Table III on the following page have been computed as outlined in Paragraph 4202.18 of Orders and Regulations using an economic life of 50 years for the project. The salvage value of the land, exclusive of improvements thereon, is based on 40 dollars per acre for the land to be taken in fee. The above value is based on the estimated cost of woodland lots which is the least expensive type of land in the reservoir area.

TABLE III

ANNUAL CHARGES

FEDERAL INVESTMENT:	
Total First Cost	$4,800,000
Interest during Construction (½ the 2-year period)	120,000
Gross Investment	$4,920,000
Less Salvage of Land	14,000
Net Investment	$4,906,000
ANNUAL FEDERAL CHARGES:	
Interest on Gross Investment at 2½%	$ 123,000
Amortization of Gross Investment, 50 years at 2½%	50,300
Maintenance and Operation, including Overhead	20,000
Interim Replacements	1,950
Total Federal Annual Charges	$ 195,250
NON-FEDERAL ANNUAL CHARGES:	
Tax Loss on Land	$ 750
Total Annual Charges	$ 196,000

W. PUBLIC HEALTH INSECT CONTROL

74. General Conditions. - Based on experience with other reservoirs constructed in New England it appears that malaria is not at present a significant health problem in this locality. There are few houses within one mile of the reservoir area. However, the flat slopes at the upper end of the conservation pool might be conducive to the propagation of vegetation and mosquitoes. It is expected that this area will be used as a source for the pervious borrow. Specifications for use of the borrow area will require that it be graded to steepen the flat beaches in the conservation pool.

75. A detailed report of the U. S. Public Health Service will be included in the Design Memorandum on Reservoir Managment.

X. FISH AND WILDLIFE RESOURCES

76. Fish and Wildlife Resources. - According to information received from the U. S. Fish and Wildlife Service, there will probably be some over-all benefit to fish and wildlife. The low flow outlet will draw water to maintain minimum flows of 4½ c.f.s. from the cooler levels of the reservoir. This will benefit a significant segment of stream below the dam and improve the reach as trout habitat.

The Fish and Wildlife Service stresses the desirability of the 4½ c.f.s. minimum flow. Protection of the bank across from the spillway will also improve the stream for trout.

77. Fish and Game interests are also considering establishment of a rainbow trout fishery in the permanent pool. They have advised that the loss of game habitat due to flooding is relatively minor. A detailed report of the Fish and Wildlife Service will be included in the Design Memorandum on Reservoir Management.

Y. HYDROPOWER

78. Hydropower. - The Flood Control Act of 1954, under which the project is authorized, provides "That penstocks and other similar facilities, adapted to possible future use in the development of hydroelectric power shall be installed in any dam authorized in this act for construction by the Department of the Army when approved by the Secretary of the Army on the recommendation of the Chief of Engineers and the Federal Power Commission". As a result of studies made for the New England-New York Inter-Agency Committee by the Corps of Engineers and the Federal Power Commission, it was found that no modifications in the project plan will be necessary to provide for the future development of hydroelectric power.

79. The Federal Power Commission has subsequently developed a plan for the utilization of the water resources of the Ashuelot River Basin which includes the proposed Otter Brook Reservoir without structural changes. The letter from the Federal Power Commission dated June 16, 1955 and outlining the plan with a copy of attachment entitled, "Possible Future Power, Otter Brook Project", is reproduced following Table II (page 28) of this memorandum. One foot should be added to the conservation pool elevations indicated in the letter. The indicated future flood control storage at the proposed Ellis Reservoir amounts to 2.9 inches on the 14 square mile drainage area. The proposed usage would not reduce the effectiveness of the Otter Brook storage.

Z. BENEFITS

80. Benefits. - a. The project is an essential unit in the comprehensive plan for flood control in the Connecticut River Basin. The comprehensive plan provides for construction of both local protective works and reservoirs. Local protective works have been constructed at 10 localities but these works are subject to failure in major floods unless flood heights are reduced by upstream storage. The upstream storage which has been provided by the construction of the five existing reservoirs is inadequate to assure the necessary high degree of flood protection.

b. Many industries are concentrated in the towns and cities along the Connecticut River and their output is of major importance in the national and regional economy and to the national defense. In case of a major flood, many of these industries would be seriously affected by flooding, loss of transportation, loss of communications and, in some instances, loss of electric power.

c. The Otter Brook Reservoir would provide flood reductions at the major damage centers on the Connecticut River. In addition, it will provide urgently needed flood protection at Keene, New Hampshire to augment the partial protection provided by the existing Surry Mountain Reservoir.

81. Average Annual Benefits.

Type	Amount
Reduction of flood damage	$ 190,000
Increased utilization of property	40,000
Total	$ 230,000

82. Benefit-Cost Ratio. - The annual cost, as shown in Paragraph 75, is $196,000. The ratio of benefits to costs is 1.2.

AA. RECOMMENDATION

83. Recommendation. - It is recommended that the project plan submitted in this report be approved as the basis for the preparation of contract plans for the Otter Brook Project.

TABLE II

DETAILED COST ESTIMATE
(1955 Price Level)
ENR Construction-Cost Index 660 (1913 = 100)

Description	Quantity	Unit	Unit Price	Amount
Preparation of site (24 Ac)	L.S.	Job		25,000
Reservoir clearing	L.S.	Job		25,000
Diversion and care of water	L.S.	Job		50,000
Common Excavation - General	225,000	C.Y.	0.95	213,750
Common Excavation - Borrow Areas "C" and "E"	781,000	C.Y.	0.85	663,850
Common Excavation - Borrow Areas "A" and "D"	83,000	C.Y.	0.90	74,700
Common Excavation - Trench	10,200	C.Y.	2.75	28,050
Rock Excavation - General	93,000	C.Y.	4.25	395,250
Mucking of Overbreak	14,800	C.Y.	0.75	11,100
Rock Excavation - Trench	50	C.Y.	7.10	355
Drilling in Rock or Concrete	1,900	L.F.	2.50	4,750
Rolled Embankment	767,000	C.Y.	0.40	306,800
Pervious Fill	59,000	C.Y.	0.40	23,600
Gravel Bedding	57,000	C.Y.	0.45	25,650
Additional Rolling	10,000	Square	0.03	300

TABLE II (Continued)

Description	Quantity	Unit	Unit Price	Amount
Rock Fill	81,000	C.Y.	0.80	64,800
Processed Gravel	500	C.Y.	2.50	1,250
Semi-compacted Random Fill	7,500	C.Y.	0.35	2,625
Unclassified Highway Fill	3,500	C.Y.	0.45	1,575
Gravel for Roads	3,000	C.Y.	2.00	6,000
Compacted Backfill	1,400	C.Y.	2.20	3,080
Cobble Gutter	300	Sq.Yd.	9.00	2,700
Corrugated Metal Pipe - 12 inch	220	L.F.	4.00	880
Topsoil	2,600	C.Y.	1.00	2,600
Mulching (2 T./Acre)	8.0	Ton	50.	400
Seeding	4.0	Ac.	600.	2,400
Portland Cement	7,000	Bbl.	5.35	37,450
Steel Reinforcement	327,000	Lb.	0.15	49,050
Anchor Bars	310	Ea.	15.	4,650
Concrete in Outlet Works	3,300	C.Y.	85.00	280,500
Concrete in Spillway Weir	720	C.Y.	55.00	39,600
Concrete in Road and Bridge Structures	240	C.Y.	95.00	22,800
Concrete Backfill	1,400	C.Y.	15.00	21,000
Grout	L.S.	Job		12,000
Copper Water Stops	1,000	Lb.	2.50	2,500
Steel Water Stops	1,000	Lb.	0.85	850

TABLE II (Continued)

Description	Quantity	Unit	Unit Price	Amount
Rubber Water Stops	1,000	Lb.	2.75	2,750
Intake Structure - Superstructure and Appurtenances	L.S.	Job		20,000
Miscellaneous Iron and Steel	20,000	Lb.	0.85	17,000
Structural Steel in Service Bridge	49,000	Lb.	0.35	17,150
Miscellaneous Structural Steel	600	Lb.	0.85	510
Miscellaneous Black Steel Pipe	500	Lb.	0.79	395
Structural Aluminum	700	Lb.	6.00	4,200
Interior Electrical System	L.S.	Job		30,000
Exterior Electric System	L.S.	Job		15,000
Hydraulic Gates and Accessories	L.S.	Job		50,000
Gate Hydraulic System	L.S.	Job		17,000
Heating System for Intake Structure	L.S.	Job		2,000
Float Well and Accessories	L.S.	Job		5,500
Monorail Hoist	L.S.	Job		1,500
Air Vent Piping	L.S.	Job		3,300
Operators Quarters	L.S.	Job		19,600
Garage	L.S.	Job		800
Utility Building - Field Office	L.S.	Job		40,000
Gasoline-Electric Standby Unit	L.S.	Job		8,500
Fire Protective System	L.S.	Job		8,000
Chain Link Fencing	2,800	L.F.	3.00	8,400

TABLE II (Continued)

Description	Quantity	Unit	Unit Price	Amount
Cattle Fencing	1,200	L.F.	2.00	2,400
Cable Guard Rail	5,100	L.F.	1.60	8,160
Curbing	150	L.F.	3.00	450
Tile Gages	L.S.	Job		3,500
Flag Pole	L.S.	Job		1,500
Pore Pressure Measuring Devices	L.S.	Job		15,000
Log Boom	L.S.	Job		5,000
Bituminous Macadam Road Surface	7,400	S.Y.	1.40	10,360
Removing abandoned road Surface	1,000	S.Y.	0.16	160
Stream Gaging Station	L.S.	Job		10,000
Miscellaneous *	L.S.	Job		20,000
DAM AND APPURTENANCES				2,755,000
Contingencies 25%				689,000
Supervision and Administration				290,000
TOTAL CONSTRUCTION COST				3,734,000
RELOCATIONS	492,000			
Supervision and Administration	40,000			
TOTAL RELOCATIONS				532,000
LANDS AND DAMAGES				234,000
Sub-total				4,500,000
ENGINEERING AND DESIGN				300,000
TOTAL FEDERAL COST				$ 4,800,000

* Includes electric and telephone wires to site, and miscellaneous operating equipment.

FEDERAL POWER COMMISSION
REGIONAL OFFICE
139 CENTRE STREET, NEW YORK 13, N. Y.

June 16, 1955

The Division Engineer
Corps of Engineers, U. S. Army
New England Division
857 Commonwealth Avenue
Boston 15, Massachusetts

Subject: Otter Brook Project
Connecticut River Basin

Dear Sir:

Reference is made to your letter dated November 19, 1954 and subsequent correspondence concerning the proposed Otter Brook Flood Control Project on which a Definite Project Report is currently being prepared in your office. In response to your request for our comments with respect to the installation of penstocks or similar facilities adapted to possible future development of hydroelectric power at the project, our office has made studies of the proposed project in combination with other potential sites in the Ashuelot River basin. Presented herein are our conclusions with respect to possible future power development at the Otter Brook Project and at other potential sites which appear to merit future consideration for flood control, power development and conservation storage in the Ashuelot River basin.

The Otter Brook Project

The Otter Brook Project, authorized by the Flood Control Act of 1954 as a part of the comprehensive flood control plan for the Connecticut River basin will be located on Otter Brook, near Keene, New Hampshire. It will provide 18,000 acre-feet of reservoir storage capacity to control the flood runoff from 47 square miles of drainage area above the dam. The combination of the existing Surry Mountain reservoir and the proposed Otter Brook and Honey Hill reservoir projects will constitute the flood control program on the Ashuelot River. The dam will be constructed of earth fill with ungated spillway and a six-foot diameter flood control outlet. The Otter Brook Project has been included in the report of the New England-New York Inter-Agency Committee for flood control only. Studies for

possible future power and storage at the project were made in connection with the NENYIAC survey, but the results were negative. Your letter of reference expresses the opinion that the proposed Otter Brook dam should be constructed without provision for future hydroelectric power at the site and without regulation storage for downstream power projects.

Studies by the Commission Staff

Several possibilities for development of power on Otter Brook were considered in conjunction with the proposed flood control project. In order to develop any dependable power at the site, power storage would be essential. This could be provided by increasing the height of dam about 20 feet. Our studies indicate that the cost of enlarging the reservoir would preclude the economic development of power at the present time or in the future.

Further study was made of possible future power development in the Ashuelot Basin and the relation of Otter Brook to such development. Dam and reservoir sites which have been studied by the New Hampshire Water Resources Board and by the Commission staff for river regulation, flood control, and power include the following: Ashuelot Pond, Stillwater, Bald Hill, Surry Mountain, Ellis Reservoir, Otter Brook, Beaver Brook, East Swanzey (Honey Hill), and Hinsdale. Surry Mountain reservoir has been constructed for flood control; Otter Brook is authorized for construction; and Honey Hill is included in the authorized flood control plan.

Of the above-mentioned potential sites, a combination of Bald Hill, Ellis Reservoir, Hinsdale and Otter Brook appears to provide a suitable plan for the utilization of the water resources of the Ashuelot River basin. The plan would provide additional storage of 52,000 acre-feet; installed capacity of 40,000 kilowatts capable of generating in the average year about 80,000,000 kilowatt-hours; and increase in the low flow of the Ashuelot River at Hinsdale by 120 cfs. As part of this plan the Ellis Reservoir would provide a regulated flow sufficient for the operation of a future power installation of 4,000 kilowatts at the Otter Brook dam under a gross head of 230 feet. The conservation pool would be raised from elevation 700 to elevation 720 and the encroachment on flood control capacity would be compensated for by equivalent flood control capacity at the Ellis Reservoir. The use of the dam for future power would involve either using the flood control outlet as a power penstock with a discharge valve which would be operated for flood control purposes when required, or by future construction of a six-foot diameter tunnel under the right abutment of the dam. The

attached sketch shows the above plan for possible future power and storage on Otter Brook. The attached tabulation shows potential power projects in the Ashuelot River basin.

Conclusions

Based on the results of our studies, it is concluded that no modifications would be required in the plans for initial construction of the Otter Brook Project in order to provide for the possible future development of its power potential, estimated at about 4,000 kilowatts.

Very truly yours,

D. J. Wait

D. J. Wait
Regional Engineer

Attachments

Potential Power Projects
Ashuelot River Basin
(Tentative plan related to Otter Brook Project)

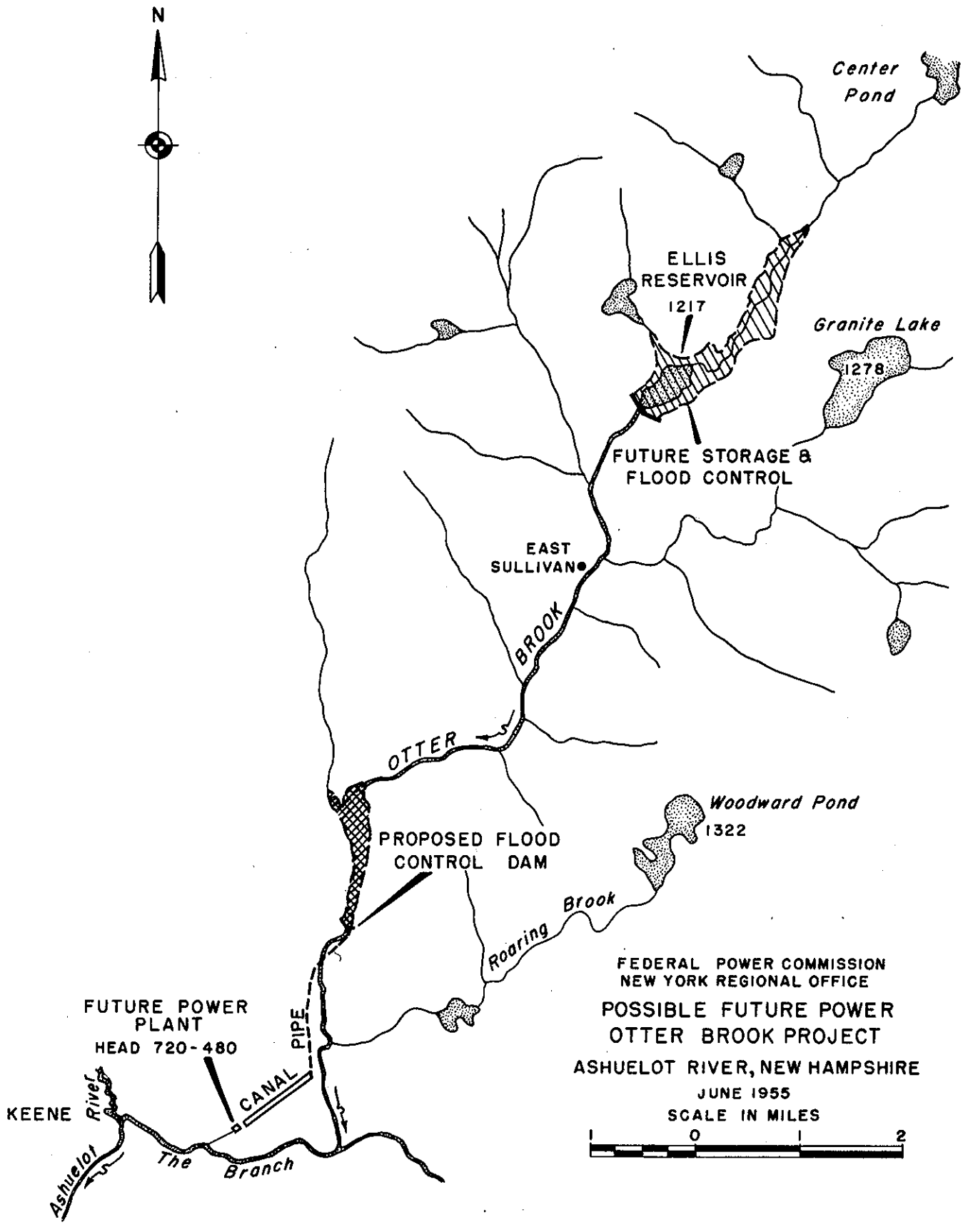
Project	Drainage Area (Sq. mi.)	Power Head (Feet)	Power Pool Elevation	Installed Capacity (KW)	Average Annual Energy (KWH)
Ellis	14	-	1,265	-	-
Otter Brook	47	230	720	4,000	8,000,000
Bald Hill	87	278	788	16,000	22,000,000
Hinsdale	410	160	395	20,000	50,000,000
Total				40,000	80,000,000

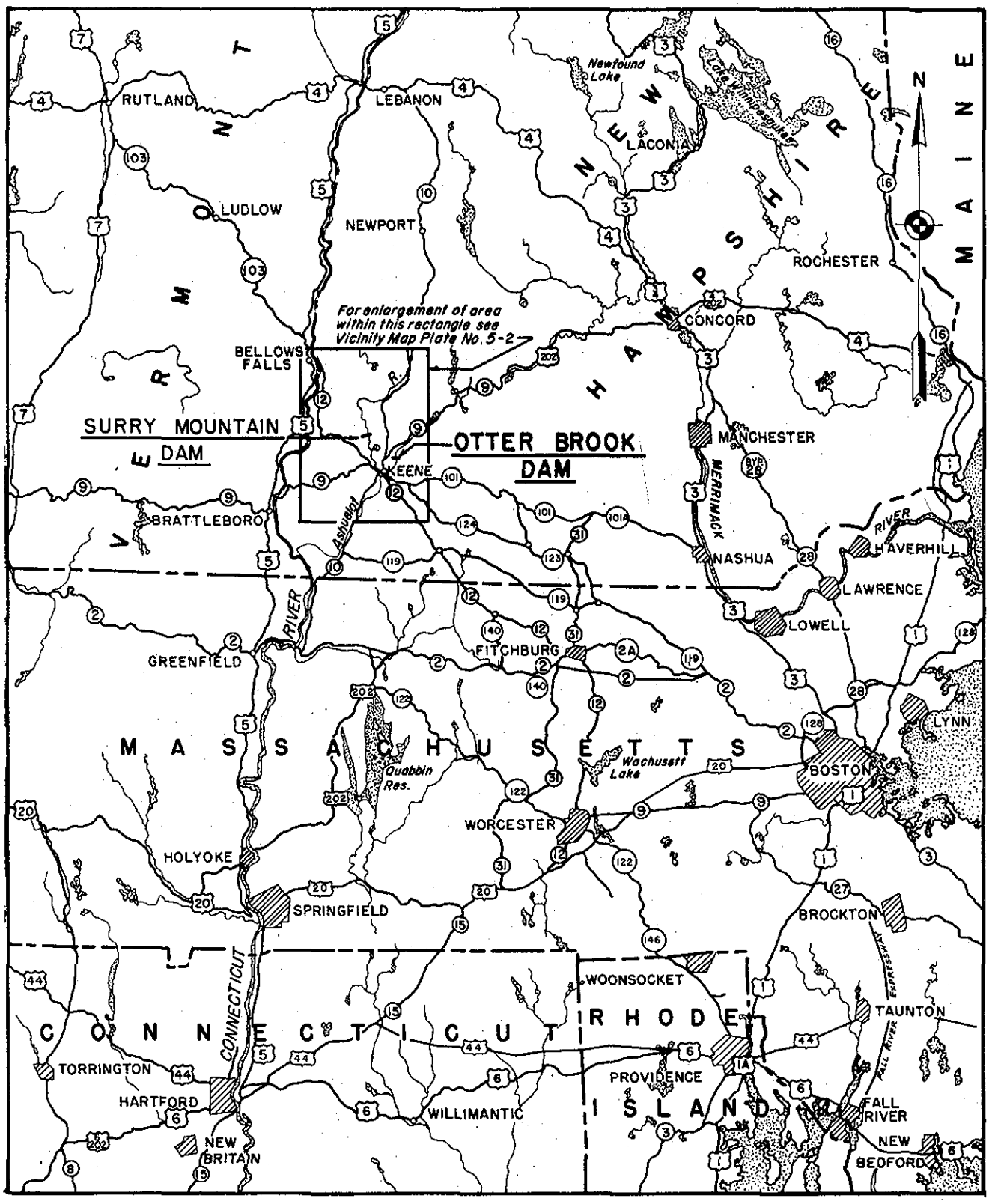
Reservoir Storage Available

	Power Storage (Acre-feet)	Flood Storage (Acre-feet)	
Ellis	10,000	4,000	
Otter Brook	Pondage	15,000	
Bald Hill	36,000	10,000	
Surry Mountain	Pondage	28,000	(Existing 32,500)
Hinsdale	Pondage	None	
Total	46,000	6,000	(increment)

Downstream Power Plants

Plant	Gross Operating Head (Feet)
Enfield	32
Holyoke	52
Turners Falls	61
Hinsdale	160
Total	305


N
Center Pond
ELLIS RESERVOIR
1217
Granite Lake
1278
FUTURE STORAGE & FLOOD CONTROL
EAST SULLIVAN
BROOK
OTTER
Woodward Pond
1322
PROPOSED FLOOD CONTROL DAM
Roaring Brook
FUTURE POWER PLANT
HEAD 720-480
PIPE
CANAL
KEENE
River
Ashuelot
The Branch
FEDERAL POWER COMMISSION
NEW YORK REGIONAL OFFICE
POSSIBLE FUTURE POWER
OTTER BROOK PROJECT
ASHUELOT RIVER, NEW HAMPSHIRE
JUNE 1955
SCALE IN MILES
0
2



LOCATION MAP

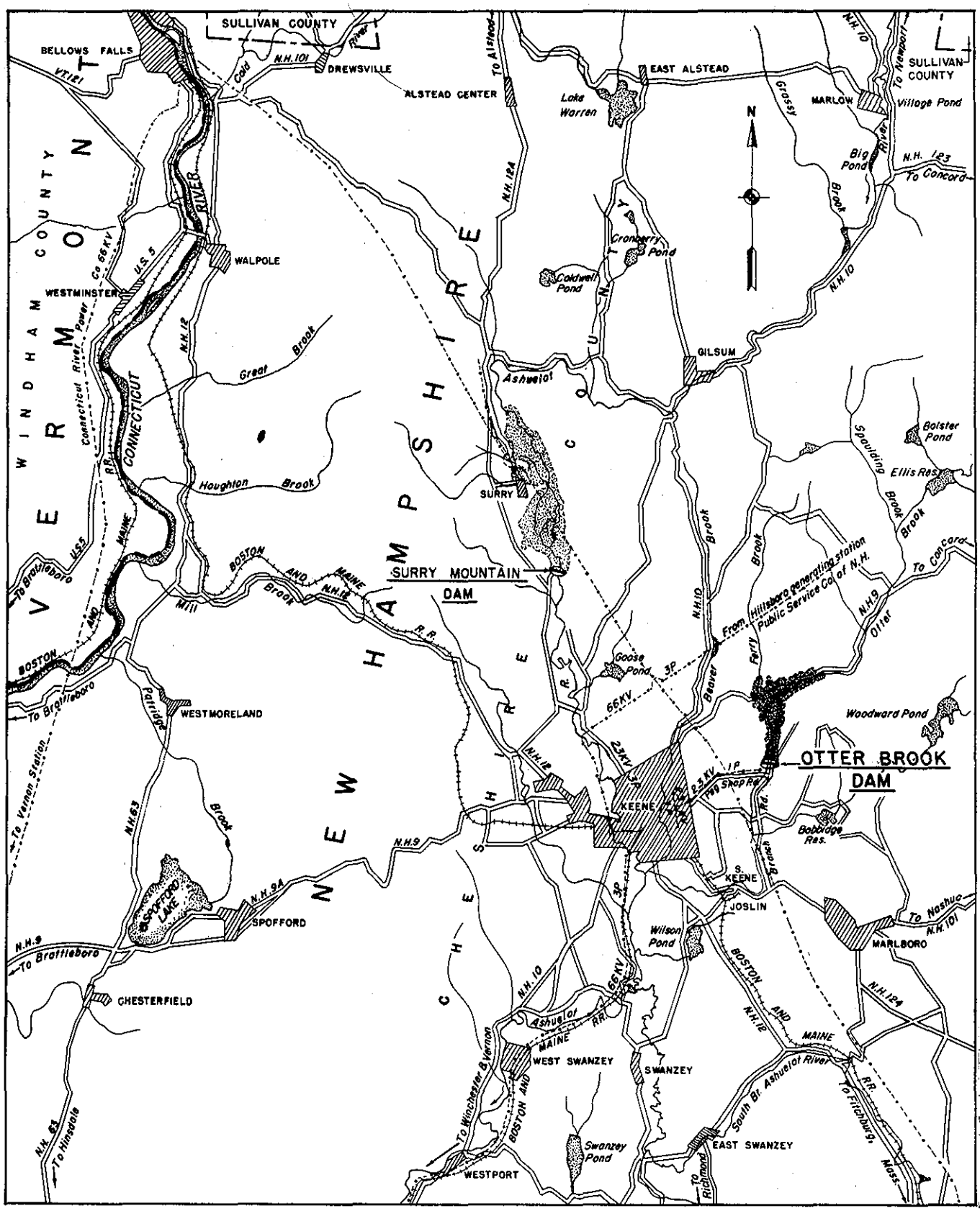
SCALE IN MILES

10 0 10 20

LEGEND

- HIGHWAYS
- (2) U.S. HIGHWAYS
- (4) STATE HIGHWAYS
- RIVERS
- STATE LINES

PLATE NO.5-1



VICINITY MAP

SCALE IN MILES
0 2

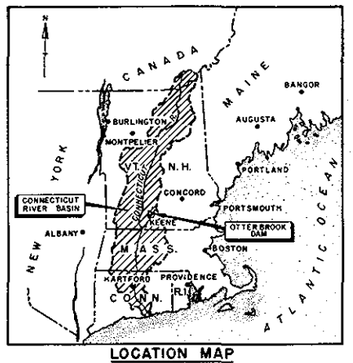
LEGEND

- HIGHWAYS
- RAILROADS
- ELECTRIC POWER LINE
- MAXIMUM RESERVOIR FLOW LINE

PLATE NO. 5-2

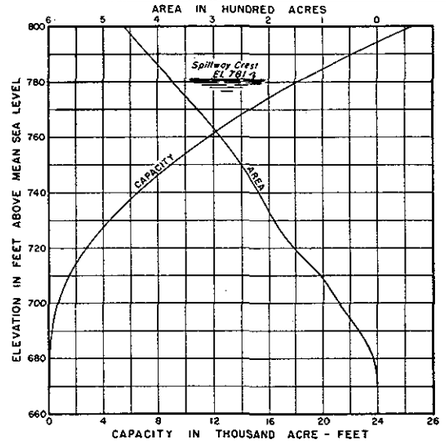
CORPS OF ENGINEERS

U. S. ARMY



LOCATION MAP

SCALE IN MILES 40 0 40 80



AREA AND CAPACITY CURVES

DRAINAGE AREA 47 SQ. MI.

Magnetic North

FLOW LINE AT SPILLWAY CREST EL. 781

RELOCATION
ROUTE 9 & BRANCH ROAD
(TENTATIVE)

DAM
SPILLWAY CREST
EL. 781

To Hillsboro

To Branch Road & S. Keene

To S. Keene

To Keene

FLOW LINE AT SPILLWAY CREST EL. 781

LEGEND

- Existing numbered routes
- Existing paved roads
- Existing gravel or secondary roads
- Existing trails
- Proposed highway relocation
- Existing fences
- Existing stone walls
- Existing utility lines
- Reservoir flow line at spillway crest, El 781

RESERVOIR PLAN

SCALE IN FEET 400 0 400 800

NOTES

Elevations refer to Mean Sea Level Datum.
Contour interval equals five feet.
Topography at damsite and vicinity reproduced from plane table surveys prepared by Corps of Engineers, dated Nov. 1954, the remaining area traced from a "Topographic Map of Roxbury, Sullivan and Keene for Project P-2413", for the State of N.H. (Dept of Public Works & Highways), dated July 1953.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

DR. BY	TR. BY	CK. BY
	M C N	J.W.L.

CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK DAM
RESERVOIR MAP

OTTER BROOK, NEW HAMPSHIRE

J.W. Nichols
PROJECT ENGINEER
SUBMITTED BY
CHIEF, ENGR. BR'TY. BRANCH
APPROVED
CHIEF, ENGINEERING DIV.

APPROVED
LT. COL., C.E. FOR THE DIVISION ENGINEER

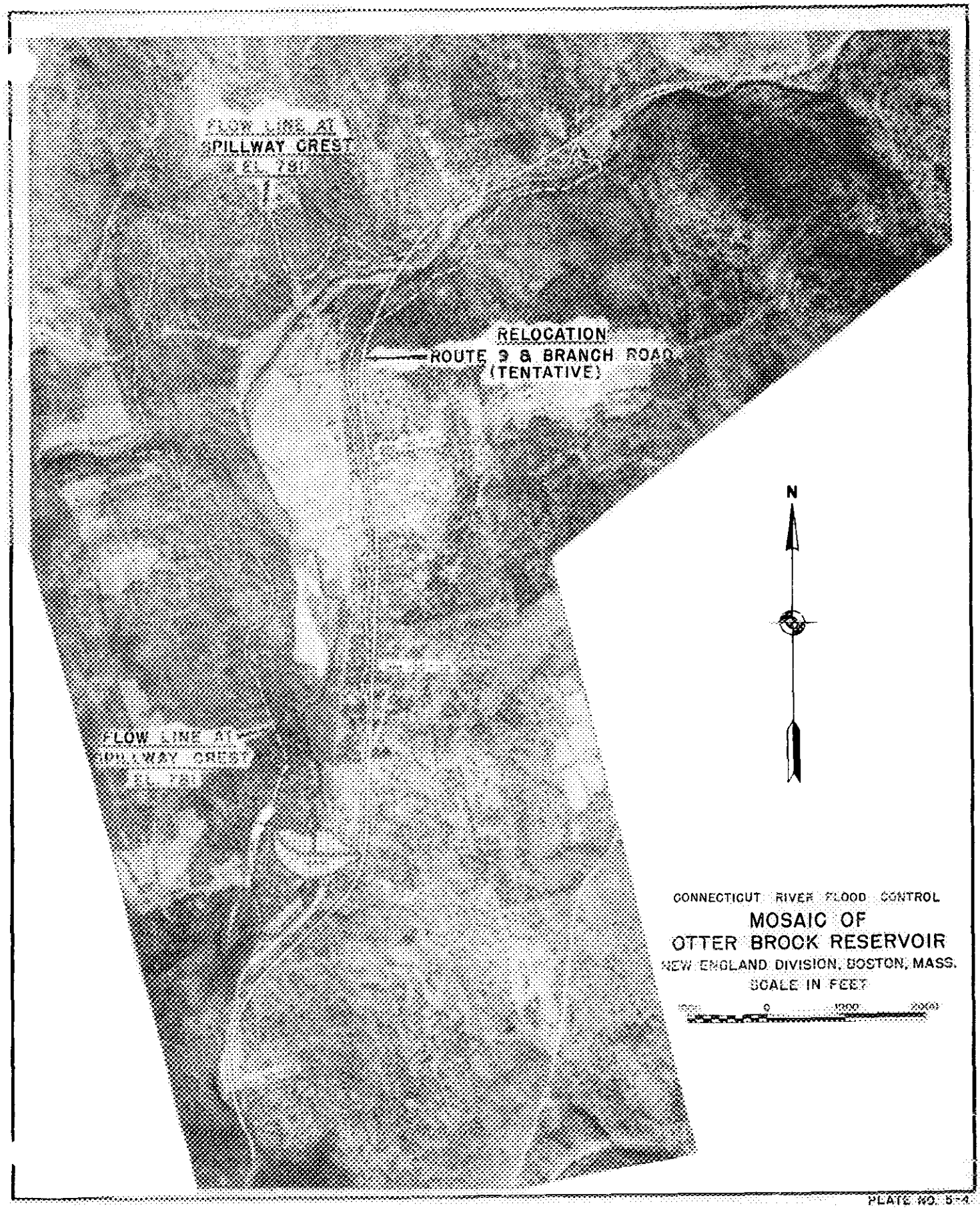
DATE JUNE 1955

SCALE-1" = 400'

DRAWING NUMBER
CT-1-4000

SHEET 1 OF 1

PLATE NO. 5-3



CONNECTICUT RIVER FLOOD CONTROL

MOSAIC OF OTTER BROOK RESERVOIR

NEW ENGLAND DIVISION, BOSTON, MASS.

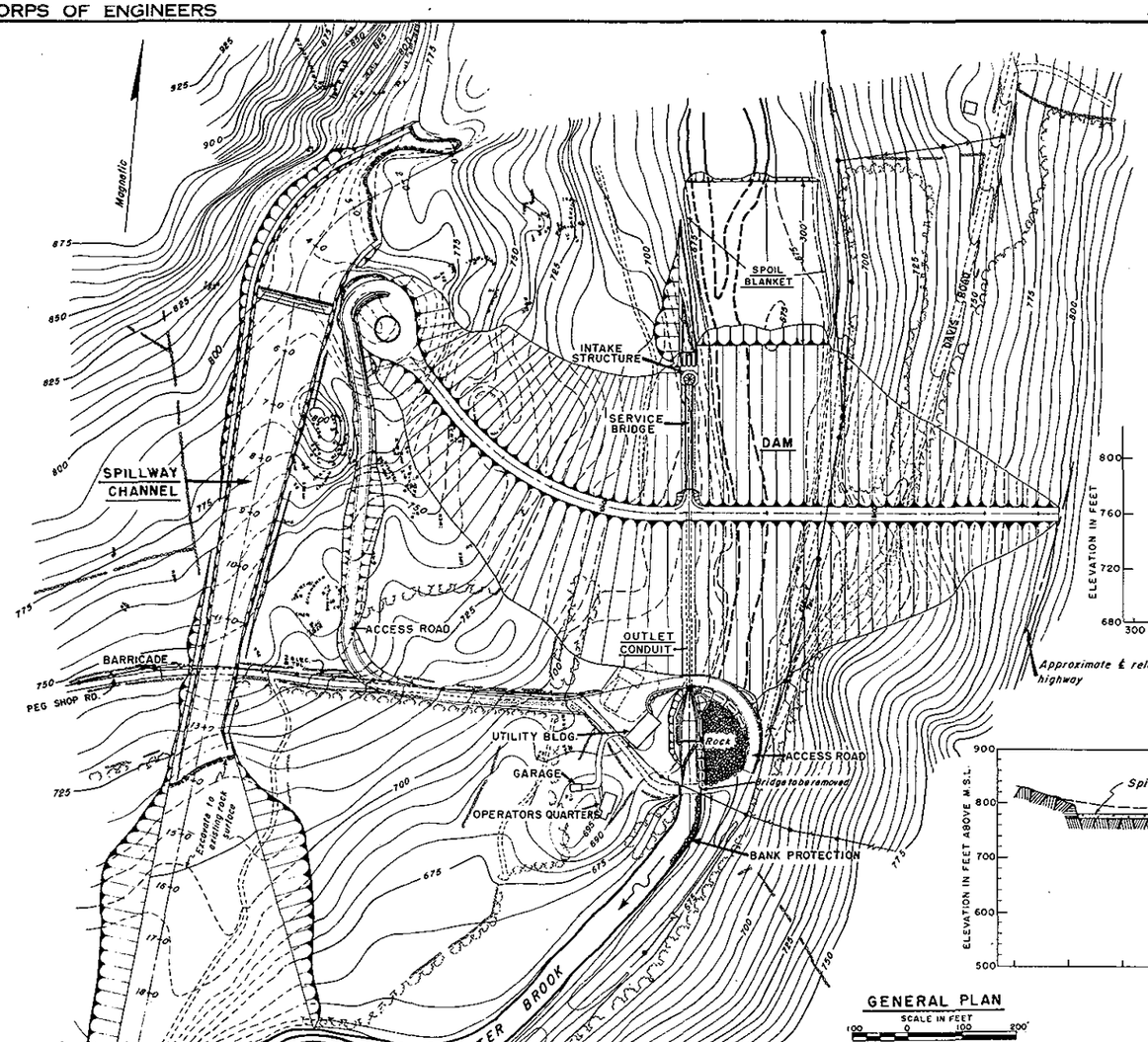
SCALE IN FEET

1000 0 1000 2000

PLATE NO. 5-4

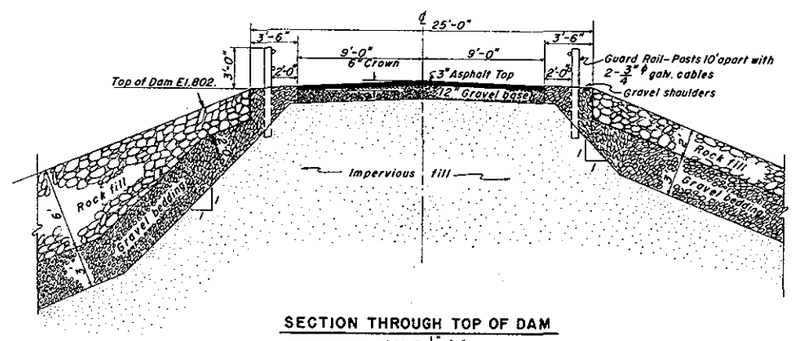
CORPS OF ENGINEERS

U. S. ARMY



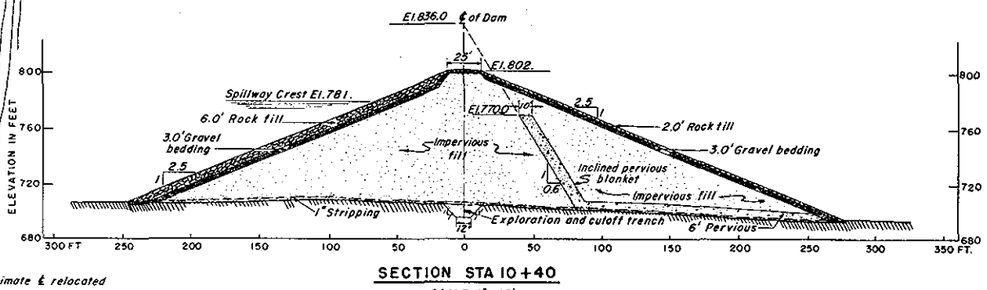
GENERAL PLAN

SCALE IN FEET 100 0 100 200'



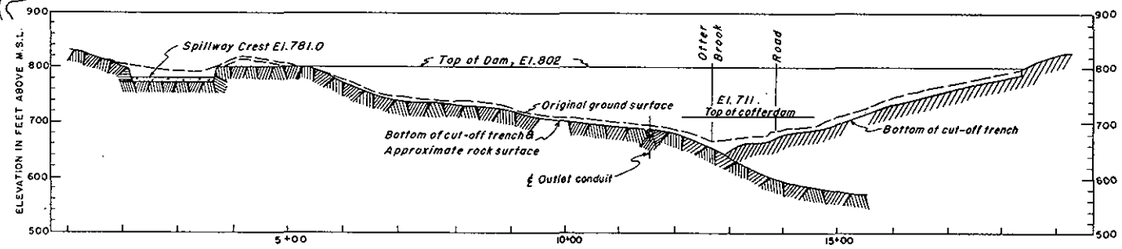
SECTION THROUGH TOP OF DAM

SCALE: 1/4" = 1'0"



SECTION STA 10+40

SCALE: 1" = 40'

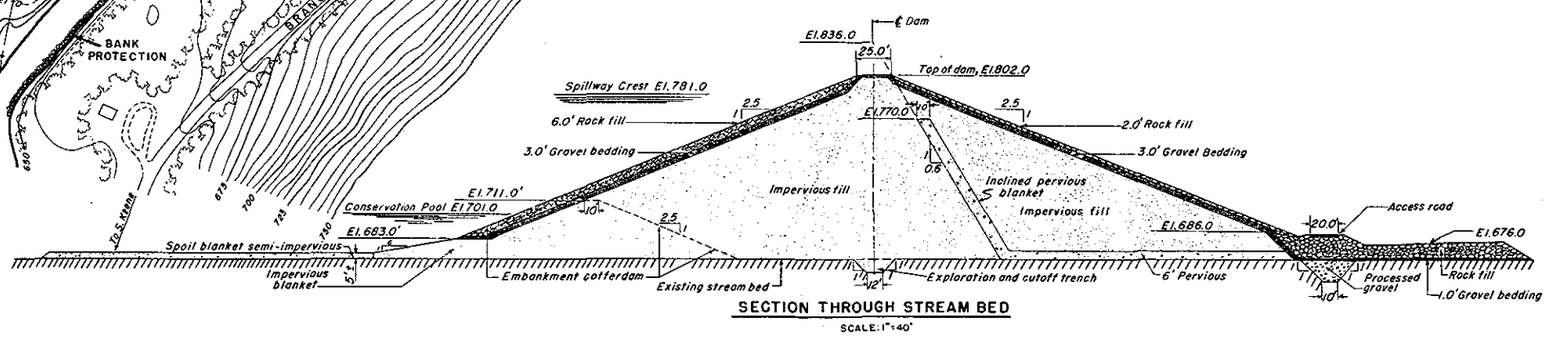


PROFILE ON ℄ OF DAM

SCALE: 1" = 100'

NOTES

Elevations refer to Mean Sea Level Datum.
Existing power and telephone lines shown on this sheet to be relocated as required.



SECTION THROUGH STREAM BED

SCALE: 1" = 40'

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
J.W.L.	S.F.C.	G.W.H.

PROJECT ENGINEER: J.W. Nichols
SUBMITTED BY: M.D. Tuttle
CHIEF PLANS & SPECS BRANCH: [illegible]
APPROVED: [illegible]
CHIEF ENGINEERING DIV.

CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK DAM

GENERAL PLAN & SECTIONS

OTTER BROOK, NEW HAMPSHIRE

APPROVED: [illegible]
DATE: JUNE 1955
LT. COL., C.E. FOR THE DIVISION ENGINEER

SCALE: AS SHOWN

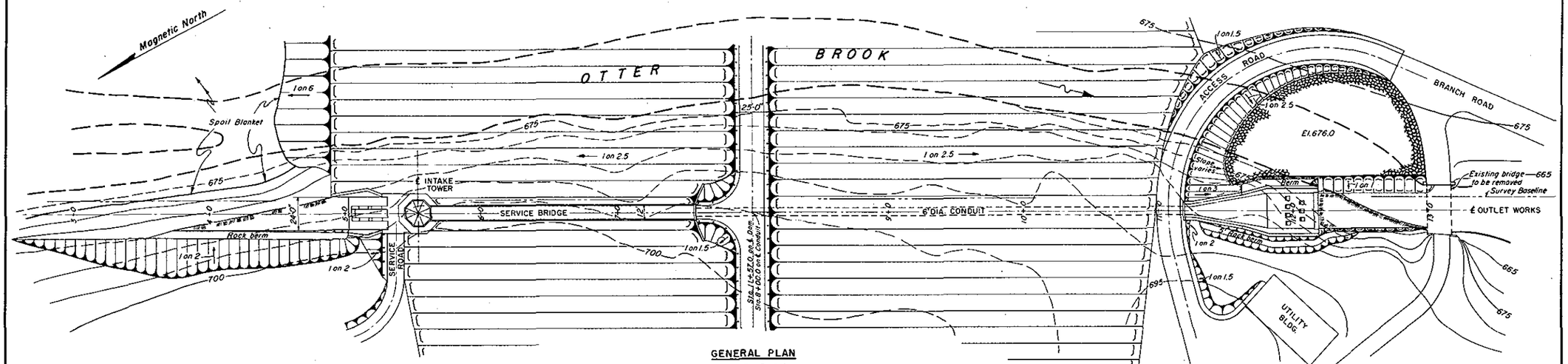
DRAWING NUMBER
CT-1-4001

SHEET 1 OF 1

PLATE NO. 5-5

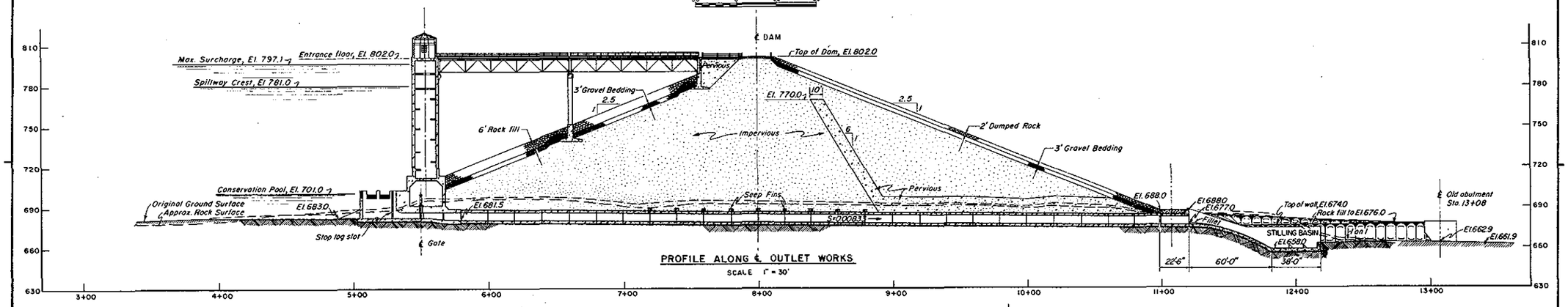
CORPS OF ENGINEERS

U. S. ARMY



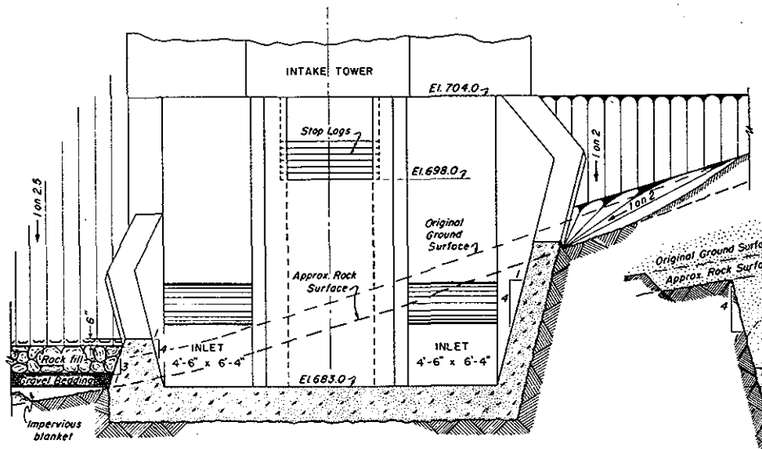
GENERAL PLAN

SCALE 1" = 30'



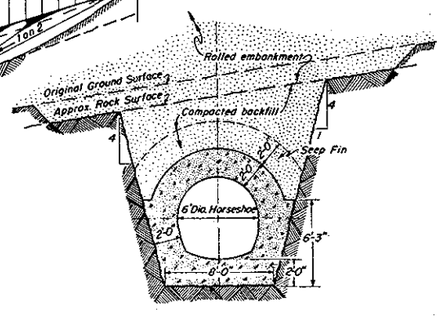
PROFILE ALONG € OUTLET WORKS

SCALE 1" = 30'



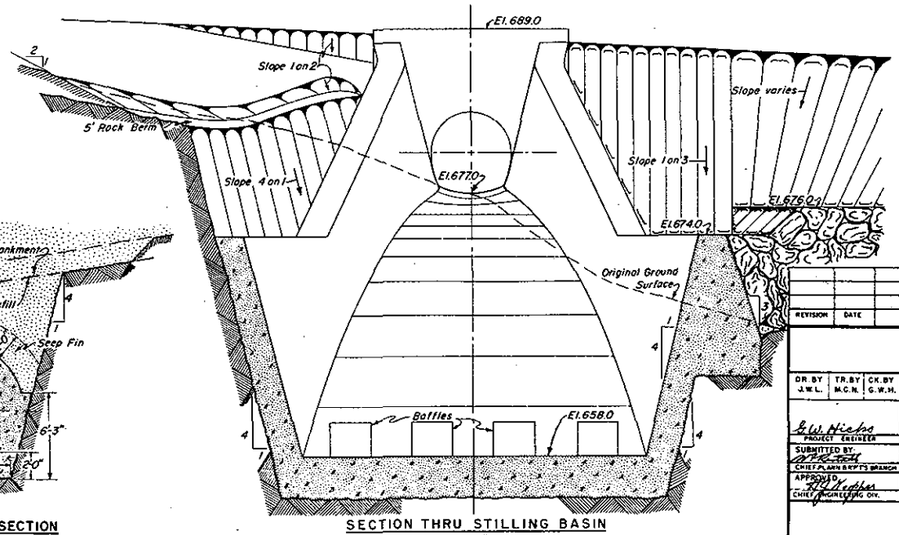
SECTION AT STA. 5+05-CONDUIT

SCALE 1/4" = 1'-0"



TYPICAL CONDUIT SECTION

SCALE 1/4" = 1'-0"



SECTION THRU STILLING BASIN

SCALE 1/4" = 1'-0"

NOTE

Elevations refer to Mean Sea Level Datum.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY J.W.L.	TR. BY M.G.N.	CK. BY G.W.H.

PROJECT ENGINEER

SUBMITTED BY: CHIEF, PLANS & SPEC'S BRANCH

APPROVED: CHIEF, ENGINEERING DIV.

APPROVED: LT. COL., C.E. FOR THE DIVISION ENGINEER

DATE: JUNE 1955

CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK DAM

OUTLET WORKS

PLAN - PROFILE & SECTIONS

OTTER BROOK, NEW HAMPSHIRE

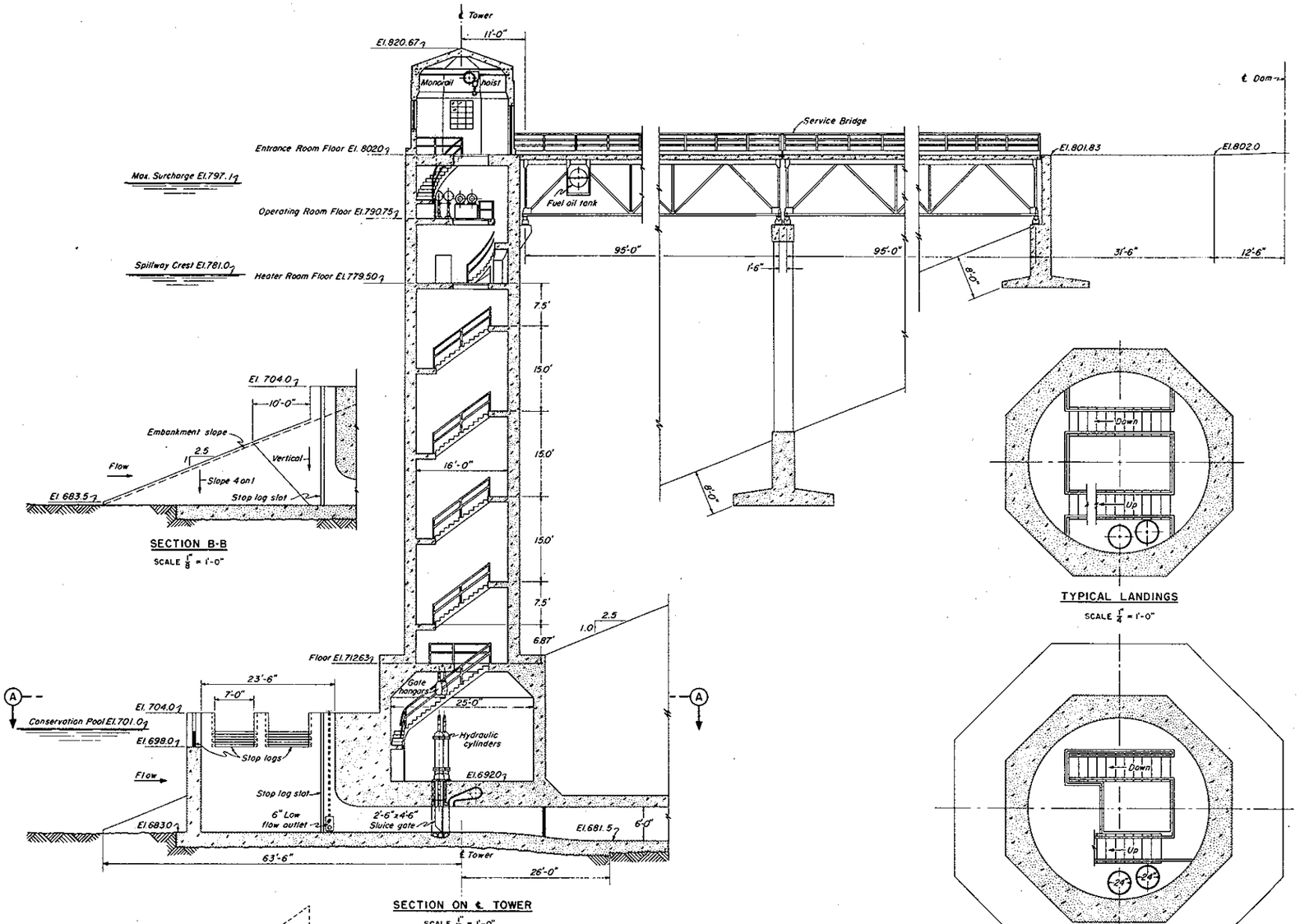
SCALE: AS SHOWN

DRAWING NUMBER CT-1-4002

SHEET 1 OF 1

PLATE NO. 5-6

CORPS OF ENGINEERS U. S. ARMY

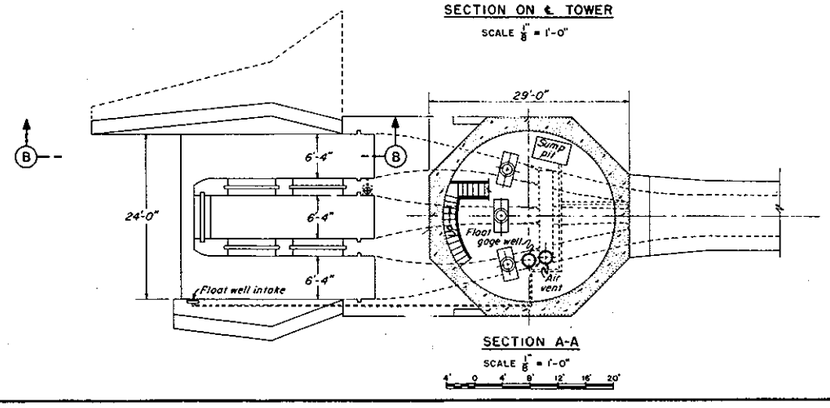


SECTION ON ℄ TOWER

SCALE 1/8" = 1'-0"

SECTION B-B

SCALE 1/8" = 1'-0"



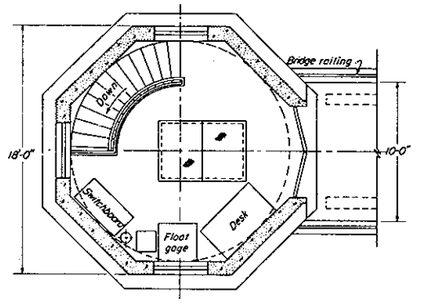
SECTION A-A

SCALE 1/8" = 1'-0"

4' 0 4' 8' 12' 16' 20'

TYPICAL LANDINGS

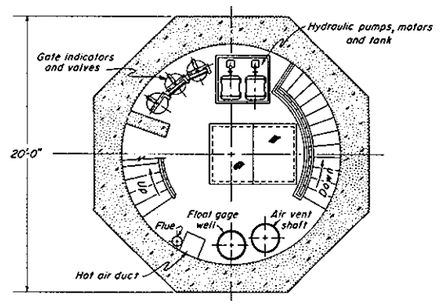
SCALE 1/4" = 1'-0"



ENTRANCE ROOM FLOOR

(EL. 802.0)

SCALE 1/4" = 1'-0"



OPERATING ROOM FLOOR

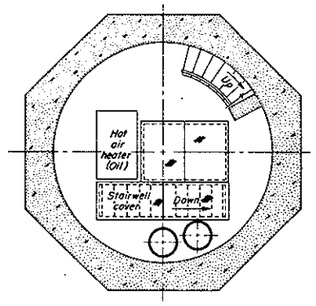
(EL. 790.75)

SCALE 1/4" = 1'-0"

FLOOR AT EL. 712.63

SCALE 1/4" = 1'-0"

4' 0 4' 8'



HEATER ROOM FLOOR

(EL. 779.50)

SCALE 1/4" = 1'-0"

NOTE

Elevations refer to M.S.L. Datum.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
J.W.L.	M.G.N.	G.W.H.

G.W. Hields
PROJECT ENGINEER

SUBMITTED BY
CHIEF, PLANS & SPEC'S BRANCH

APPROVED
CHIEF ENGINEERS DIV.

CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK DAM

INTAKE STRUCTURE

OTTER BROOK, NEW HAMPSHIRE

APPROVED
LT. COL. C.E. FOR THE DIVISION ENGINEER

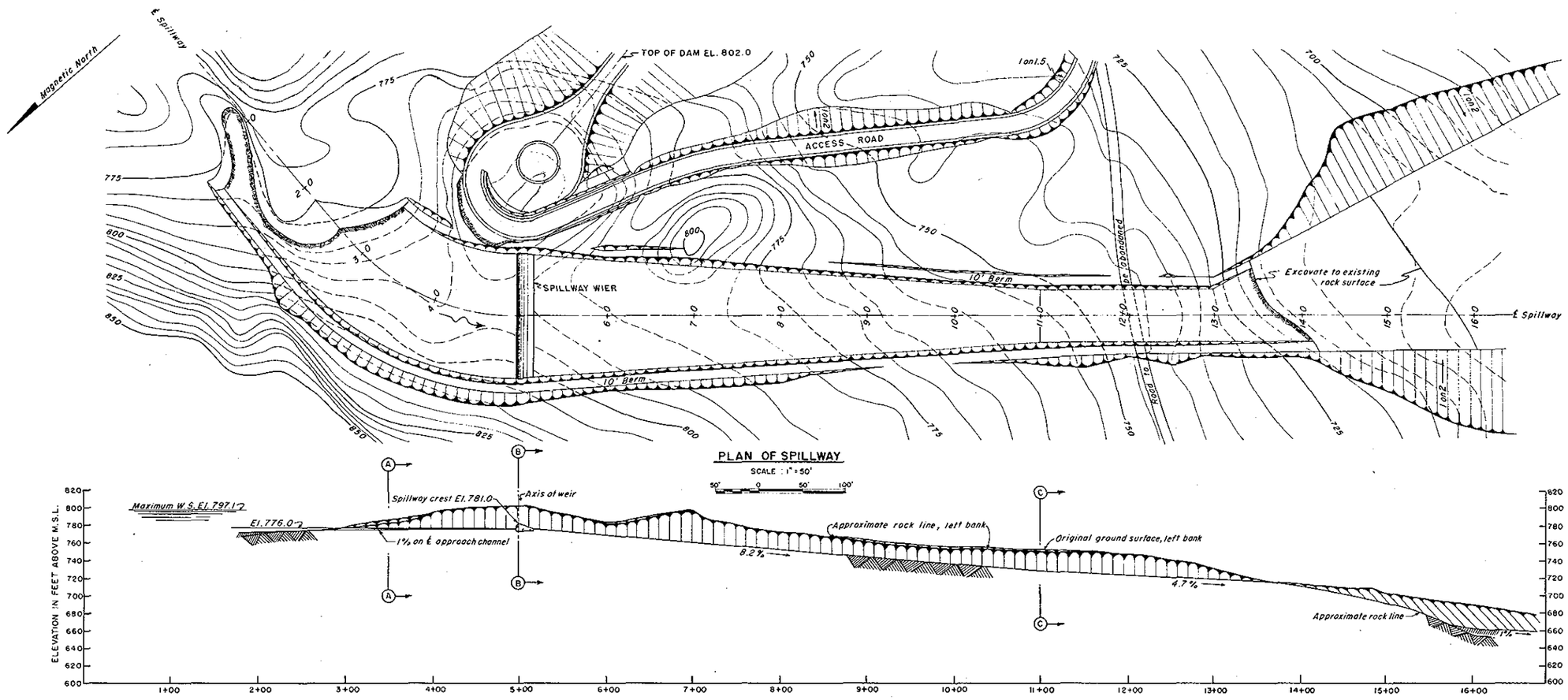
DATE JUNE 1955

SCALE: AS SHOWN

DRAWING NUMBER
CT-1-4003

SHEET 1 OF 1

PLATE NO. 5-7

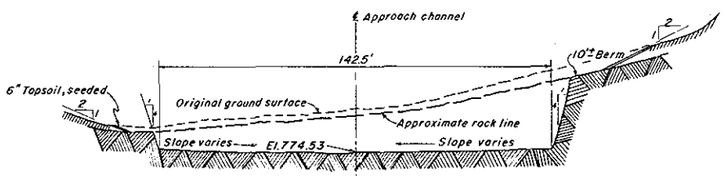


PLAN OF SPILLWAY

SCALE : 1" = 50'

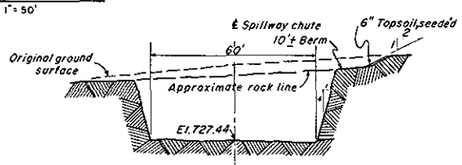
PROFILE ON ℄ SPILLWAY

SCALE : 1" = 50'



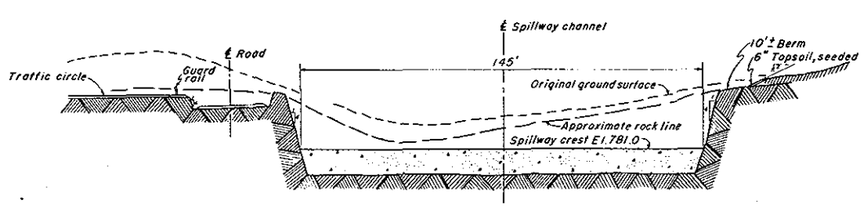
SECTION A-A STA. 3+50

SCALE : 1" = 20'



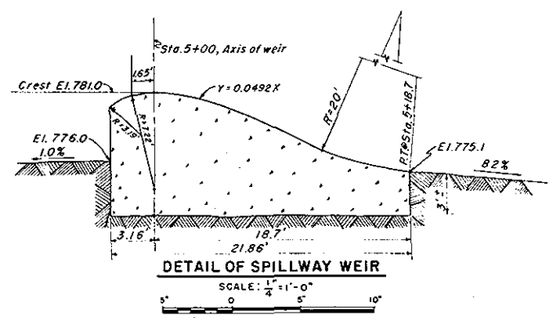
SECTION C-C STA. 11+00

SCALE 1" = 20'



SECTION B-B STA. 5+00

SCALE: 1" = 20'



DETAIL OF SPILLWAY WEIR

SCALE: 1/4" = 1'-0"

NOTE:
Elevations refer to Mean Sea Level Datum.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

DR. BY	TR. BY	CK. BY
F.B.S.	S.F.C.	J.W.L.

G.W. Hicks
PROJECT ENGINEER

SUBMITTED BY
CHIEF, PLANS & SPEC'S BRANCH

APPROVED
CHIEF ENGINEERS, DIV.

APPROVED
LT. COL., C.E. FOR THE DIVISION ENGINEER

CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK DAM
SPILLWAY
PLAN-PROFILE & SECTIONS

OTTER BROOK, NEW HAMPSHIRE

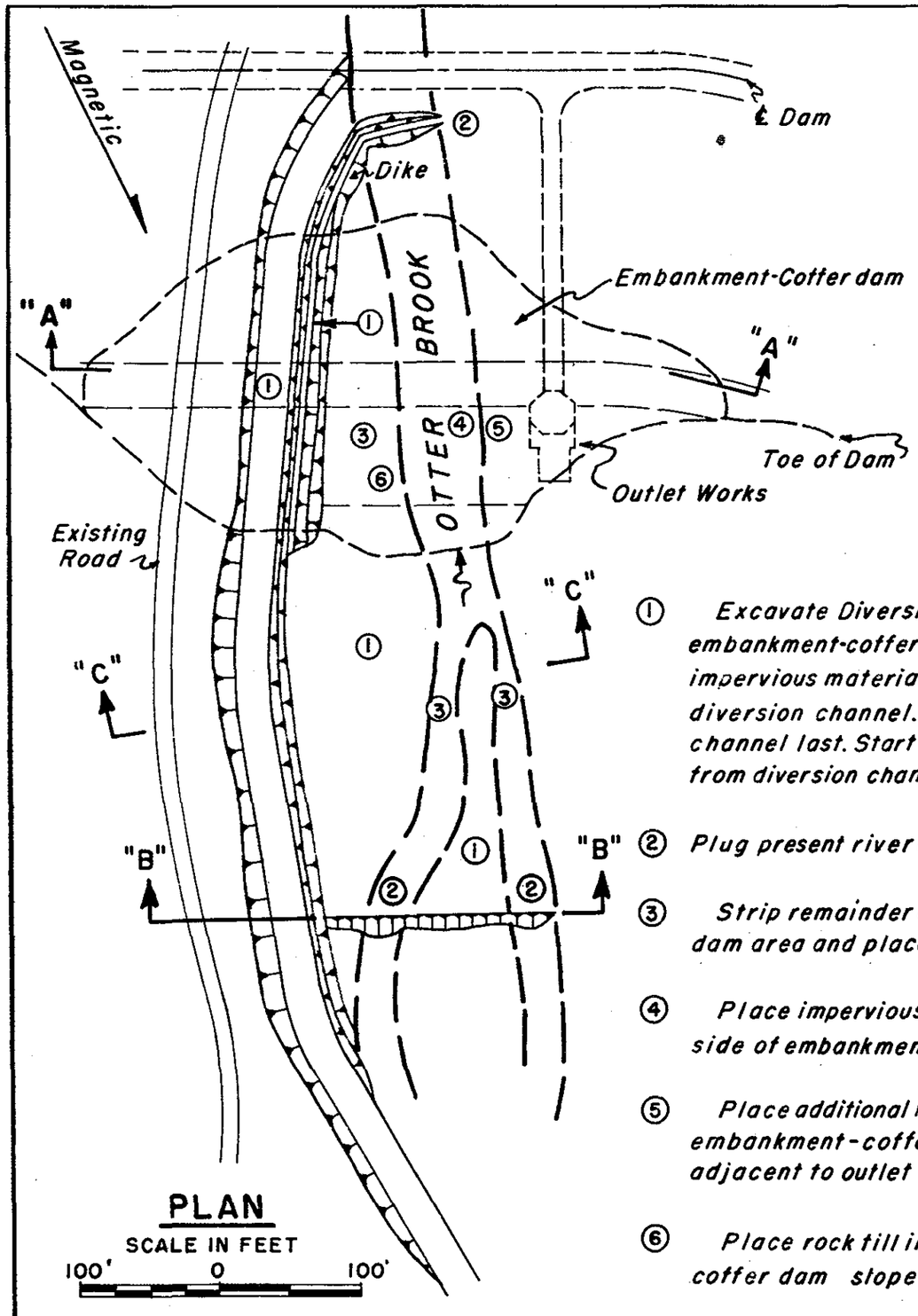
DATE JUNE 1955

SCALE: AS SHOWN

DRAWING NUMBER
CT-1-4004

SHEET 1 OF 1

PLATE NO. 5-8



PLAN

SCALE IN FEET

100' 0 100'

① *Excavate Diversion Channel. Strip in embankment-coffer dam area and place impervious material as right bank of diversion channel. Excavate ends of channel last. Start upstream spoil blanket from diversion channel excavation.*

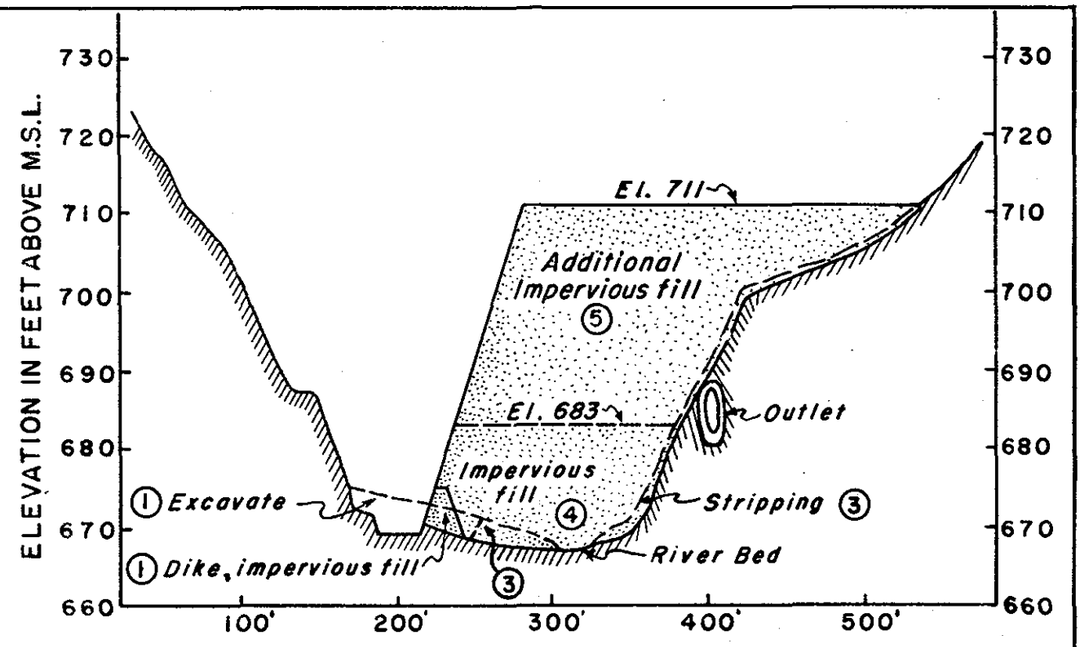
② *Plug present river channel.*

③ *Strip remainder of embankment coffer dam area and place spoil to fill river channels.*

④ *Place impervious fill to El. 683 in west side of embankment coffer-dam.*

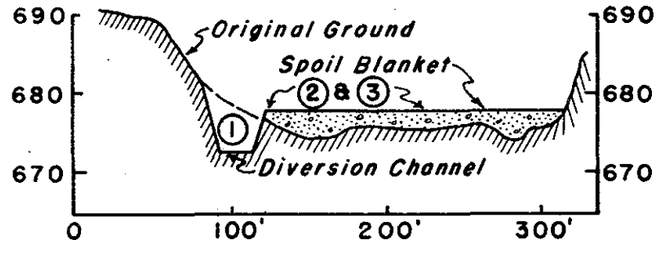
⑤ *Place additional impervious fill in west side of embankment-coffer dam delaying if necessary adjacent to outlet works.*

⑥ *Place rock fill in west portion of embankment-coffer dam slope to at least El. 687.*



SECTION "A-A"

SCALE AS SHOWN



SECTION "B-B"

SECTION "C-C" IS SIMILAR
SCALE AS SHOWN

CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK DAM

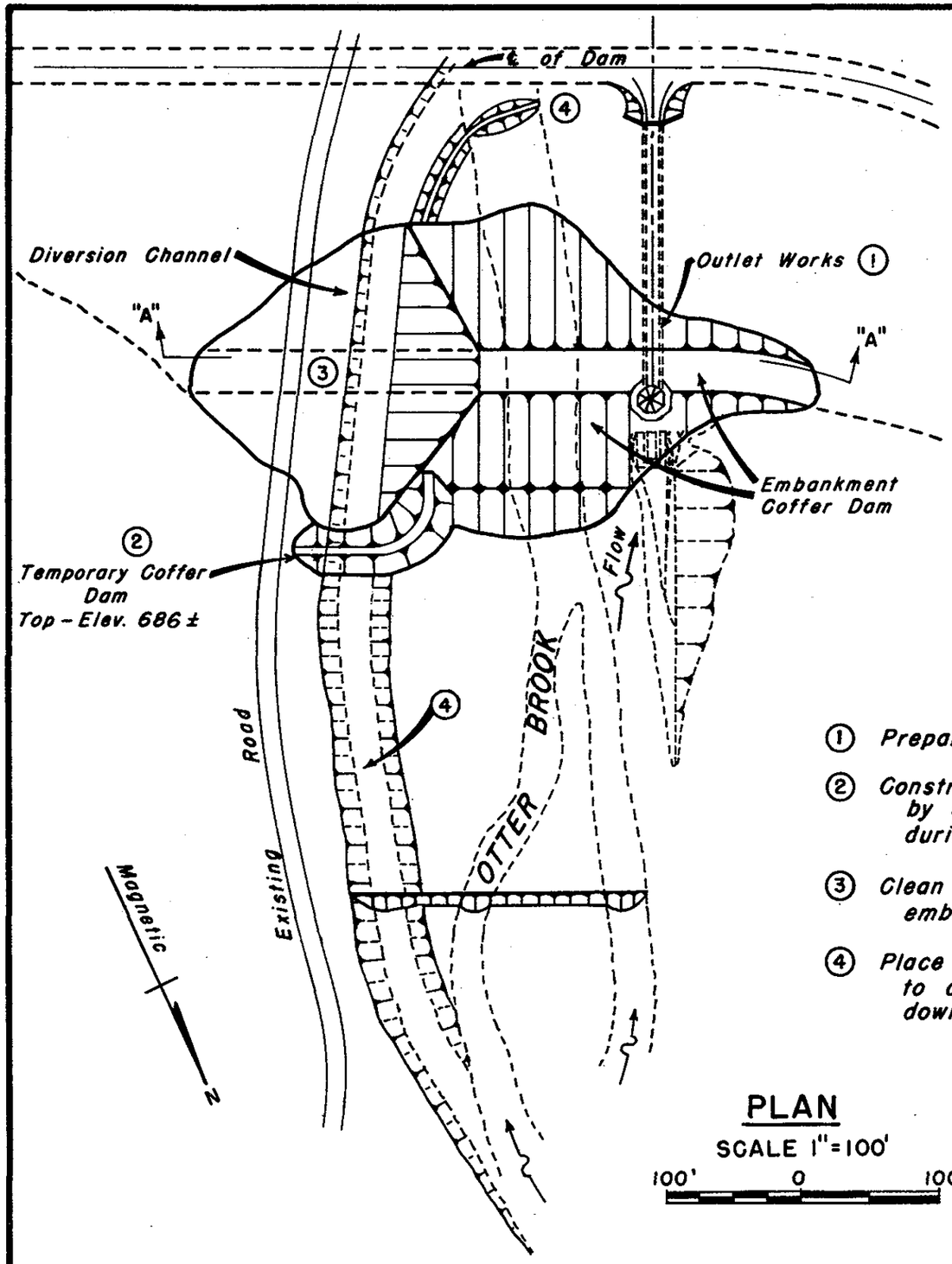
DIVERSION PLAN

STAGE I

SCALE AS SHOWN

MAY 1955

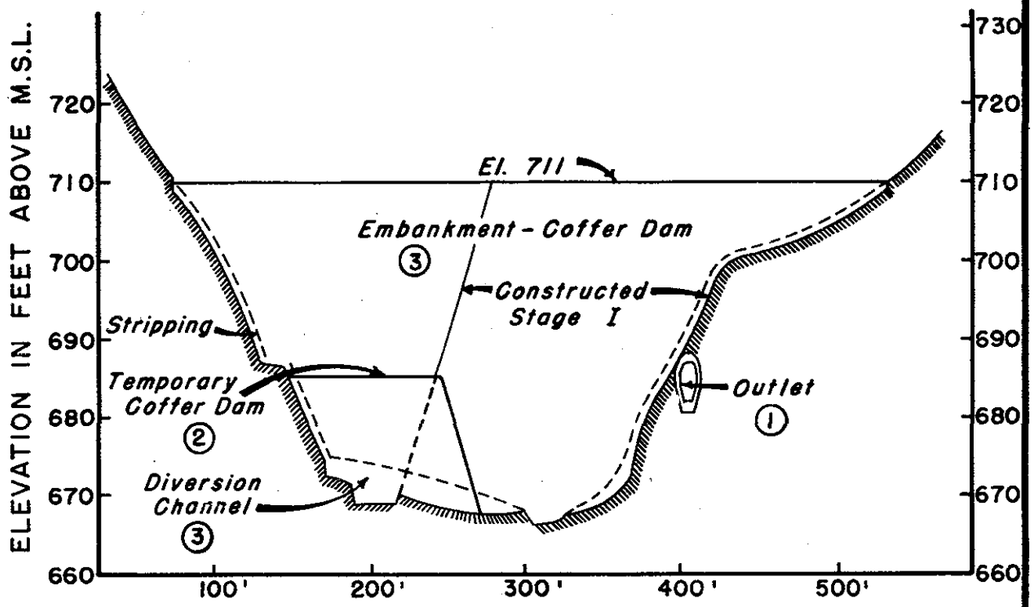
PLATE NO. 5-9



PLAN

SCALE 1"=100'

100' 0 100'



SECTION "A-A"

SCALE AS SHOWN

(1) *Prepare outlet works for diversion. Block gates open.*

(2) *Construct temporary coffer dam in diversion channel by dumping spoil or random material into water during period of moderate flow.*

(3) *Clean diversion channel, strip east side, and complete embankment - coffer dam.*

(4) *Place spoil in upstream portion of diversion channel to complete upstream spoil blanket. Remove temporary downstream cofferdam.*

CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK DAM

DIVERSION PLAN

STAGE II

SCALE AS SHOWN

MAY 1955

PLATE NO. 5-10

OTTER BROOK RESERVOIR
OTTER BROOK

CONSTRUCTION SEQUENCE AND FISCAL YEAR FUND SCHEDULE

LEGEND: Types of Activity
Preconstruction — Construction

LINE NO.	UNIFORM COST CLASSIFICATION	FEATURE	PROJECT COST ESTIMATE	TOTAL TO 30 JUNE 1955	FISCAL YEARS 1956	1957	1958	1959
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	01.	LANDS AND DAMAGES	234,000			164,000	70,000	
2								
3	02.	RELOCATIONS	(492,000)			(492,000)		
4	.1	Roads	451,000			451,000 *		
5	.3	Utilities	41,000			41,000 *		
6								
7	03.	RESERVOIRS	(37,000)			(15,000)		(22,000)
8		Clearing	31,000			15,000		16,000
9		Log Boom	6,000					6,000
10								
11	04.	DAM	(3,253,000)			(448,000)	(1,515,000)	(1,290,000)
12		Non-overflow section	1,663,000				813,000	850,000
13		Spillway	791,000			50,000	500,000	241,000
14		Outlet Works	799,000			398,000	202,000	199,000
15								
16	08.	ROADS, RAILROADS AND BRIDGES	(30,000)			(5,000)	(5,000)	(20,000)
17		Roads	30,000			5,000	5,000	20,000
18								
19	19.	BUILDINGS, GROUNDS AND UTILITIES	(94,000)			(58,000)	(2000)	(34,000)
20		Operators quarters	24,000					24,000
21		Operational buildings	51,000			51,000		
22		Utilities	17,000			7,000	2,000	8,000
23		Grading and Landscaping	2,000					2,000
24								
25	20.	PERMANENT OPERATING EQUIPMENT	30,000			15,000		15,000
26								
27	30.	ENGINEERING AND DESIGN	300,000	95,000	152,000	20,000	26,000	7,000
28								
29	34.	SUPERVISION AND ADMINISTRATION	330,000	5,000	8,000	83,000	122,000	112,000
30								
31		TOTAL FEDERAL COSTS	4,800,000	100,000	160,000	1,300,000	1,740,000	1,500,000
32								
33		* INCLUDES OBLIGATIONS UNDER RELOCATIONS CONTRACT						
34								
35								
36								

PLATE NO. 5-11